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Vol. III. 1892.

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AND

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— OF —

The Geographical Society of the Pacific

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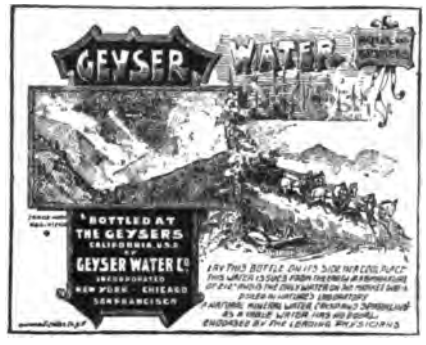

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PAPERS READ BEFORE

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1881.

Oct. 10—"Memorandum upon the Relation of Plover Island to Wrangel Land," by the President, Prof. Geo. Davidson.

Oct. 10—"The Universal Meridian," by H. Bouthillier de Beaumont, President of the Geographical Society of Geneva. Read by Francis Berton, Esq., Consul for Switzerland.

Nov. 15—"The Topography, Ethnography, and the Natural and Mineral Resources of Sinaloa, Mexico," by Fred. Wiedner, Esq., Surveyor-General of Sinaloa.

Nov. 23—"New Caledonia," by Capt. Bruno, Honorary Equerry to H. M. the King of Italy.

Dec. 13—"The Cruise of the Corwin in the Arctic, 1881," by Capt. C. L. Hooper, U. S. R. M.

Dec. 20—"The Circuit of the Magnetic Pole," illustrated by instruments, by Th. E. Slevin, Esq., LL.D.

1882.

Jan. 24—A Cast of the Isthmus of Panama, showing the direction of the Canal, and of the work done up to date; exhibited by Eugene de Sabla, Esq., Consul for Peru.

Jan. 24—"Capt. Dallman's claim to the discovery of Wrangel Land," translated from the Bulletin of the Geographical Society of Bremen.

Feb. 28—"From the Naas to the Skeena, British Columbia," by George Chismore, Esq., M. D.

Mar. 28—"Memoir of the River and Harbor of Guayaquil," by Pedro Carlo; translated from the Spanish by Th. E. Slevin, Esq., LL. D.

Apr. 25—"A Visit to the Galapagos Islands," by Hon. B. B. Redding.

June 27—"Glaciers," and his ascent of Mount Rainier, Washington Territory, 1857, by Gen. A. Kautz, U. S. A.

July 11—"Reminiscences of Paraguay," by Hon. C. A. Washburn.

Aug. 8—"Civilization in South America," by Hon. C. A. Washburn.

Aug. 22—"A Glimpse of Egypt," by Col. Richard D. Savage, U. S. A.

Sept. 12—"Mount Etna" and "Volcanoes," by Hon. J. F. Swift.

Oct. 10—"The Early Inhabitants of America," by Th. E. Slevin, Esq., LL.D.

Oct. 24—"The Transit of Venus," by the President, Prof. Geo. Davidson, Ph. D., Sc. D.

Nov. 14—"The Discovery of America by the Norsemen," by C. Mitchell Grant, Esq., F. R. G. S.

Nov. 28—"Impressions and Experiences of the Chinese during his Journey to Pekin," by Hon. John F. Swift, U. S. Commissioner to China.

Dec. 12—"Concepts of Space," by W. Irving Stringham, Esq., Professor of Mathematics, University of California.

1883.

Jan. 9—"The Natives of South Africa," by Surgeon Major Sketchley.

Jan. 23—"Arctic Ice Notes," by Capt. C. L. Hooper, U. S. R. M.

Jan. 23—"Salvador," by Alex. Laidlaw, Esq.

Feb. 13—"Southern Africa, including a description of the Diamond Fields," by Surgeon Major Sketchley.

Feb. 27—"Experiences in the Lava Beds during the Modoc War," by Major Trimble, U. S. A.

Feb. 27—"The Topography, Geology and Natural and Mineral Resources of Alaska," by W. D. Patterson, Esq.

Mar. 13—"Time," by Th. E. Slevin, Esq., LL.D.

Mar. 27—"Corrections of the Coast Line of Alaska," by Ivan Petroff, Esq.

Apr. 10—"The Native Tribes of Alaska," by Ivan Petroff, Esq.

Apr. 27—"Japan," by Hon. John F. Swift.

May 8—"Japan," by Hon. John F. Swift.

May 22—"Early Arabian Intercourse with China," by Gerritt L. Lansing.

June 13—"Notes on Russia," by Colonel Gowan.

June 26—"Samoa and Its People," by Theodore A. Lord, Esq.

July 10—"Western Mexico," by R. P. Hammond, Jr., Esq. C. E., U. S. Surveyor General.

July 24—"The Basques, their Country, and Fueros," by Th. E. Slevin, Esq., LL. D.

Aug. 14—"Pompeii," by Hon. John F. Swift.

Aug. 31—"The Scenery, Resources and Railways of Oregon," by Alfred A. Wheeler, Esq.

Sept. 11—"Missionary Influence in Samoa," by Theodore A. Lord, Esq.

Sept. 25—"Among the Mahlemutes; or Sled Journeys in Northwestern Alaska," by Henry D. Woolfe.

Oct. 9—"Wanderings in Spain," by Hon. Alex. Del Mar.

Oct. 23—"Forestry," by Hon. C. A. Washburn.

Nov. 27—"Aztec Calendar or Solar Stone at Mexico," by E. J. Molera, Esq., C.E.

1884.

Jan. 15—"Madagascar, Its Past and Present," by J. Studdy Leigh, Esq., F.R.G.S.

Feb. 19—"Pyramids of Teotihuacan," by E. J. Molera, Esq., C.E.

Mar. 5—"Chili, Bolivia and Peru," by J. Studdy Leigh, Esq., F.R.G.S.

Mar. 19—"Tonquin, Anam and French Cochin China," by C. Mitchell Grant, F.R.G.S.

Apr. 1—"The Seat of War in Egypt," by Hon. Alex. Del Mar.

Apr. 15—"The Change of Position of the Earth's Axis," by Th. E. Slevin, Esq., LL.D.

May 6—"American Antiquities," by Hon. S. C. Hosmer, Chief Justice of Montana.

May 20—"Shoaling of the Bar at the Entrance of San Francisco Harbor," by the President, Prof. Geo. Davidson, Ph. D., Sc. D.

June 3—"British Guiana," by John Finlay Finlayson, Esq.

June 17—"The Geography of Siam, and the Religion, and Manners, and Customs of the Siamese," by C. Mitchell Grant, Esq., F.R.G.S.

July 15—"The Yellowstone Park," by Miss S. E. Hosmer.

Aug. 15—"The Greeley Expedition," by Th. E. Slevin, LL.D.

Sept. 2—"The First Ascent of Volcano Makushkin," by Prof. George Davidson, Sc. D., Ph. D.

Sept. 16—"Ancient Gold Mines in Italy," by Hon. Alex. Del Mar.

Oct. 7—"Chili, Its Physical and Political Features," by Col. Birkedel.

Oct. 21—"Travels in Idaho," by P. W. Poulson, M.D.

Dec. 2—"The Arctic Explorations of Dr. Kane," by Chief Justice Hon. S. C. Hosmer.

Dec. 16—"Guatemala to London," by A. G. Magee, H.B.M., Consul at Guatemala.

1885.

Jan. 6—"Across the Andes," by T. B. Gunning, Esq., of New York.

Jan. 20—"Zanzibar," by J. Studdy Leigh, F.R.G.S.

Feb. 3—"The Ophir of the Ancients," by Mr. Charles Reed.

Feb. 17—"Notes on Earthquakes in Japan," by F. A. Cope, Esq.

Mar. 3—"The Phœnix Group," by John A. Arundel, Esq., F.R.G.S.

Mar. 17—"Europe, during the Reign of Napoleon III," by Hon. John F. Swift.

Apr. 21—"Corea," by the Rev. C. S. Eby, B.A.

May 5—"India," by Mr. Joshu.

May 19—"Japan," by Consul General Van Buren.

June 16—"The Political Aspect of India," by J. Studdy Leigh, Esq., F.R.G.S.

July 21—"The Greely Expedition," by Maurice Connell, one of the survivors.

Aug. 4—"Alaska," by Professor James Denman.

Aug. 18—"Sledge Journeys in the Arctic," by Maurice Connell, Esq.

Sept. 1—"Travels in South America," by Louis Degener, Esq., F.R.G.S., Vienna.

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Dec. 1—"Arctic Travel," by Charles Farciot, Esq.

Dec. 16—"The Earth as Altered by Placer Mining," by Hon. Alex. Del Mar.

1886.

Feb. 13—"The Soudan," and Personal Reminiscences of General Gordan, by F. A. Colby.

Mar. 13—"Eads Ship Railway Across the Isthmus of Tehuantepec," by L. F. Moulton.

Mar. 26—"Mount Whitney and the Geography of Inyo County," by Capt. J. M. Keeler.

Apr. 16—"Panama Canal," by Ernst Von Hesse Wartegg.

May 13—"The Legislation of Ancient Rome," by T. E. Slevin, Vice-President.

May 28—"Geography and History of the Kingdom of Corea," by Dr. Geo. W. Wood, U.S.N.

July 21—"A Topographical Description of the Great Yukon River of Alaska," by Dr. Willis E. Everette.

Aug. 17—"The Relative Enjoyments of Savage and Civilized Life," by John S. Hittell.

Oct. 19—"Explorations on the Koo Wuk in Alaska," by Lieut. John C. Cantwell, U.S.R.M. (Read by Prof. Geo. Davidson.)

Nov. 16—"The Legislation of Ancient Rome," by T. E. Slevin, Vice-President.

Dec. 7—"The Times Expedition to Icy Bay and Mount St. Elias," by H. W. Seton Karr, F.R.G.S. (Read by Prof. George Davidson)

1887.

Jan. 4—"The Plains and Hills of Hungary," by Hon. Alex. Del Mar.

Jan. 18—"Mounds in the Canadian Northwest," by Chas. N. Bell.

Feb. 15—"Mount St. Elias," by Prof. Geo. Davidson, Sc. D., Ph. D.

Mar. 15—"The Trend of the Ocean Current which runs in the Arctic Sea off the Alaskan Shores," by Henry D. Woolfe.

Apr. 5—"The Introduction of Gold and Silver Mining in Various Ages," by Hon. Alex. Del Mar.

Aug. 2—"Experience in the Arctic Basin, and Travels in Siberia in Search of De Long and his Boat's Crew," by J. H. Bartlett, one of the Survivors of the Jeanette Expedition.

Aug. 16—"Experience in Northern China," by Geo. Bromley, U. S. Consul for Tientsin.

Sept. 6—"Northern Sonora," by Ferdinand Lee Clarke.

Oct. 4—"Hawaiian Islands," by Ferdinand Lee Clarke.

Dec. 6—"Oxford and its University," by Arthur Inkersley, B.A.

1888.

Mar. 6—"Rambles in Europe," by Col. Stuart Taylor.

Apr. 3—"Ceylon to Bombay via Delhi," by Hon. Jeremiah Lynch.

Apr. 17—"Sinaloa, Sonora and Jalisco," by Dr. E. Von Hasslocher.

May 1—"Travels in Syria," by Consul Louis E. Degener.

Oct. 2—"The Dispersion of the Aryans," by Adley H. Cummins.

Dec. 4—"Reminiscences of Hawaii," by Prof. Albert Lyser.

Dec. 18—"The Semitic Race," by Adley H. Cummins.

1889.

Feb. 5—"Arctic Currents," by Dr. P. W. Poulson.

Mar. 28—"The Identification of Sir Francis Drake's Anchorage on the Coast of California in the Year 1579." by Prof. George Davidson, Ph.D., Sc.D.

May 7—"Australia," by Prof. Adolph Herbst.

Aug. 10—"Currents in the Pacific," by Prof. George Davidson, Ph.D.Sc.,D.

Aug. 20—"Stanley's Journey Across Africa," by C. Mitchell Grant, F.R.G.S.

1890.

Mar. 4—"The Discovery of Humboldt Bay," by Prof. Geo. Davidson, Ph.D., Sc.D.

"The Anglo Portuguese Dispute, and the Territories on the East Coast of Africa under British and German Influence," by C. Mitchell Grant, F.R.G.S.

June 12—"The Cannibal Aborigines of Australia," by Dr. Carl Lumholtz.

Aug. 12—"Western Washington," by John S. Hittell.

Sept. 23—"The Physical and Social Aspects of the Island of Moemotu," (Caroline Islands, South Pacific Ocean,) by Mrs. Emily S. Loud.

Oct. 23—"The Ascent of Mount St. Elias," by Mark B. Kerr.

Nov. 25—"Travels in Eastern Africa, by J. A. Harrington.

1891.

Jan. 13—"Geographical and Ethnological Notes on Alaska." by Ivan Petroff, U. S. Special Agent in charge of the Alaska Census.

Jan 27—"The Heart of Africa," by Capt. Edward B. Coode Hore, F.R.G.S.

Feb. 10—"Corea, the Hermit Kingdom," by John T. Scott, Esq.

Apr. 23—"The Life History of the Sierra Nevada," by James T. Mills, Esq.

May 13—"British India, with Reminiscences of the Sepoy Mutiny," by Capt. E. Murray Cookesley, H.M.S. Illustrated with Stereopticon Views.

June 12—"The Nicaragua Canal," by Senator Warner Miller, of New York.

Aug. 18—"Picturesque Japan," by Donald Downie, B. C. L.

Sept. 28—"Geography and Ethnography of East Africa," by F. W. D'Evelyn.

Oct. 20—"Columbus and His First Voyage of Discovery," by Thos. E. Slevin, LL.D.

Dec. 10—"The Philippine Islands," by Alex. F. Oakey, Esq.

1892.

Jan. 27—"Mexican Vistas," by E. J. Molera, C. E.

Feb 17—"The Nicaragua Canal; its Geography and Technique," by Capt. W. L. Merry.

Mar. 29—"Alaska," by Rev. J. Q. A. Henry,

Apr. 12—"The Philippine Islands," by Alex. F. Oakey, Esq.

May 10—"Atlantis, a Romance of Geography," by H. M. Du Bose, D.D.

May 17—"The Nicaragua Canal," by Hon. Warner Miller.

Sept. 13—"Asiatic Cholera; its History and Geographic Home," by W. F. McNutt, M.D., L.R.C.S., L.R.C.P.

Oct. 11—"The Weather and Storm Phenomena," by Lt. Jno. P. Finley, U.S.A.

Oct. 27—"Recent Visual and Photographic Astronomy," by Prof. E. E. Barnard, Lick Observatory.

Dec. 9—"The Islands of the Pacific," by John F. Arundel, F.R.G.S.

LIST OF

Geographical and Other Scientific Bodies,

WITH WHICH THIS SOCIETY EXCHANGES PUBLICATIONS,

ALASKA:
Alaskan Society of Natural History and Ethnology, Sitka.

ARGENTINE REPUBLIC.
Academia Nacional de Ciencias, Cordoba.
Instituto Geográphico Argentino, Buenos Aires.
Sociedad Geográphica Argentina, Buenos Aires.

AUSTRALIA:
Royal Geographical Society of Australasia.
—New South Wales, Branch.
—Victoria, Branch.
—Queensland, Branch.
—Society of Victoria.

AUSTRIA:
K. K. Geographische Gesellschaft, Vienna.

BELGIUM:
Société Belge de Geógraphie, Antwerp.
Académie Royale de Belgique, Brussels.
Société Royale Belge de Géographie, Brussels.

BRAZIL:
Instituto Historico, Geographico, e Ethnographico do Brazil, Rio Janeiro.

CANADA:
Geological Society, Quebec.
Geographical and Natural History Survey of Canada, Ottawa.
Royal Society of Canada, Ottawa.

CHILE:
Der Deütsche Wissenschaftliche Verein, Santiago.
Observatorio Astrónomico, Santiago.

CHINA:

China Branch of the Royal Asiatic Society, Shanghai.

DENMARK:

Royal Danish Academy of Sciences, Copenhagen.
Royal Danish Geographical Society, Copenhagen.

EGYPT:

Société Khédiviale de Géographie, Cairo.

FINLAND:

La Société de Géographie, Helsingfors.

FRANCE:

Société de Géographie, Lille.
Société de Géographie, Lyons.
Société de Géographie, Marseilles.
Société de Géographie, Paris.
Société de Géographie, Rochefort.
Société de Géographie, Rouen.
Société de Géographie, Saint Nazaire.
Société de Géographie, Toulouse.
Société de Géographie, Tours.
Société de Géographie Commerciale, Bordeaux.
Société de Géographie Commerciale, Havre.
Société de Géographie Commerciale, Paris.
Société Languedocienne de Géographie, Montpellier.
Union Géographique du Nord de la France, Douai.

GERMANY:

Geographische Gesellschaft, Bremen.
Geographische Gesellschaft, Carlsruhe.
Geographische Gesellschaft, Hamburg.
Geographische Gesellschaft, Hanover.
Geographische Gesellschaft, Jena.
Geographische Gesellschaft, Lübeck.
Geographische Gesellschaft, Munich.
Gesellschaft für Erdkunde, Berlin.
K. Gesellschaft der Wissenschaften, Leipzig.
Naturforschende Gesellschaft, Emden.
Naturwissenschaftliche Verein für Schleswig-Holstein, Kiel.
Verein für Erdkunde, Darmstadt.
Verein für Erdkunde, Dresden.
Verein für Erdkunde, Leipzig.
Verein für Erdkunde, Metz.

GREAT BRITAIN AND IRELAND:
Manchester Geographical Society, Manchester.
Royal Asiatic Society, London.
Royal Geographical Society, London.
Royal Scottish Geographical Society, Edinburgh.
Tyneside Geographical Society, Newcastle-upon-Tyne.
Victoria Institute, London.

GUATEMALA:
Direccion General de Estadistica, Guatemala.
Ministerio de Fomento, Guatemala.

HUNGARY:
Hungarian Geog. Society, Buda-Pest.

ITALY:
Societa Geographica Italiana, Rome.

JAPAN:
Asiatic Society, Yokohama.
Geographical Society, Tokio.

JAVA:
Bataviaasch Genootschap Van Kunstan en Wetenschappen, Batavia.

MEXICO:
Observatorio Astronomico Nacional de Tacubaya, Mexico.

NETHERLANDS:
Aardijks, Genootschap, Amsterdam.

NEW ZEALAND:
The New Zealand Institute, Wellington.
Polynesian Society, Wellington.

PORTUGAL:
Sociedade de Geographia, Lisbon.

ROMANIA:
Societatea Geog. Română, Bucharest.

RUSSIA:
Imperial Russian Geographical Society, St. Petersburg.
Société de Géographie Finlandaise, Helsingfors.

SWEDEN:
Society for Anthropology and Geography, Stockholm.

SWITZERLAND:

Société de Géographie, Geneva.
Société de Géographie de Neuchâtel, Neuchâtel.

UNITED STATES:

American Geographical Society, New York, N. Y.
Appalachian Mountain Club, Boston, Mass.
Bureau of Education, Washington, D. C.
Bureau of Ethnology, Washington, D. C.
California Academy of Sciences, San Francisco, Cal.
California Historical Society, San Francisco, Cal.
Chief of Engineers, War Department, Washington, D. C.
Coast and Geodetic Survey, Washington, D. C.
Department of State, Washington, D. C.
Geological Survey, Washington, D. C.
Historical Society of Southern California, Los Angeles, Cal.
Leland Stanford Jr. University, Palo Alto, Cal.
Library of Congress, Washington, D. C.
Library of Harvard University, Cambridge, Mass.
Library of Yale University, New Haven, Conn.
Mercantile Library Association, San Francisco, Cal.
National Geographic Society, Washington, D. C.
Naval Institute, Annapolis, Md.
Office of Library and War Records, Navy Department, Washington, D. C.
Oneida Historical Society, Utica, N. Y.
Smithsonian Institution, Washington, D. C.
State Library, Boston, Mass.
State Mining Bureau, San Francisco, Cal.
Tacoma Academy of Sciences, Tacoma, Wash.
University of California, Berkeley, Cal.
U. S. Commission of Fish and Fisheries, Washington, D. C.

NOTES BY THE SECRETARY.

The Society enters upon the fourth quarter of its twelfth year, with brighter prospects than it has had since its foundation in 1881. Beginning with a small number of members, it has grown slowly and steadily, ever aiming to make a meritorious record in disseminating among the public a knowledge of all countries.

Its utility and authority in the field of scientific research on this coast have long been acknowledged.

The increased numbers attending the meetings show the interest taken in scientific lectures.

The audiences are much larger than formerly, and this necessitates the use of spacious lecture halls.

The Society was represented at the International Geographical Congress held at Genoa, Italy, in October last, by the Chevalier Ernst Von Hesse-Wartegg, and by Professor Wm. Carey Jones; and at the Congress of Americanists, held at Huelva, Spain, the same month, by Knight Commander J. F. Loubat. Several invitations to other European assemblages were received, but the presence of cholera caused the postponement of these meetings.

Capt. H. G. Morse, of the Oceanic S. S. Co.'s Steamer Alameda; Dr. T. J. Le Tourneux, of this city; Capt. Z. L. Tanner, U. S. N., commanding U. S. Str. Albatross; Capt. Michael A. Healey, commanding U. S. Rev. Str. Bear; Capt. C. L. Hooper, commanding U. S. Rev. Str. Corwin; and Capt. W. C. Coulson, commanding U. S. Rev. Str. Richard Rush, have promised to read papers before the Society in the near future.

During the year 1892 ten lectures were given, all very fully attended.

In accordance with our By-laws, lectures are omitted for two months in the summer, a large proportion of the members being then absent from town.

JOHN PARTRIDGE,
Secretary.

Some Facts About Weather and Storm Phenomena.

ILLUSTRATED WITH STEROPTICON VIEWS.

BY LIEUT. JOHN P. FINLEY, U. S. ARMY.

The vicissitudes of the weather have long excited the attention of the world. Men have studied meteorology more or less systematically ever since the time of Aristotle, who wrote the first treatise on the subject, yet little progress was made until the invention of the barometer and thermometer, the former by Torricelli in 1643, and the latter by Galileo in 1592.

Prof. Robt. H. Scott, Director of the British Meteorological Office, in his recent well-written work on meteorology, says: "We must admit that even yet it has hardly made good its title to a place among the exact sciences."

The reason for this apparently slow advancement may be traced to the following causes: 1. We live at the bottom of the atmospheric ocean, of which the upper layers are practically inaccessible, and their condition almost unknown to us. 2. The observations we make of the physical state of the air are affected to such a degree by local accidents, such as the elevation, contour and slope of the ground, its nearness to the sea, and even the character of the soil, that we meet with considerable variations of meteorological circumstances, even within the limits of a single county. In this respect meteorology affords a strong contrast to astronomy. The objects of observation and study in the latter science are at such a distance from the earth that it is practically of minor importance whether they be observed from Greenwich, Rome or Washington. The phenomena themselves are identical, and, other things being equal, the difficulties of making the observation depend largely upon the meteorological conditions of the locality. In fact, under favorable meteorological circumstances, the range of phenomena observable by an astronomer

is limited solely by the horizon of his station and the power of his telescope. But in meteorology the case is widely different; the phenomena are not the same at two different points of observation. Take, for example, a single element, the temperature of the air. In the streets of a great city the heat conditions differ materially from those experienced at the same time in the middle of the parks, and *a fortiori* from those existing entirely without the city. Hence the necessity for covering the country with a network of independent meteorological stations, as the observer at each place cannot do much more than record the phenomena exhibited by the portion of the atmosphere actually in contact with his instruments.

Meteorology may be considered from many different points of view. In the first instance, observations taken systematically at one place give eventually information as to the climate of that place, and when the results obtained for one such station are combined with those for other stations and compared with those taken in other countries, deductions may be drawn bearing upon the relative fitness of different localities for the support of animal and vegetable life, etc. From this climatological point of view, the subject is immediately related to the science of physical geography, and in a greater or less degree to sanitary science also, and it is in this connection that it has been longest and most perseveringly studied.

The highest object of meteorological science is attained when we consider it a department of cosmical physics and the problems solved involve the investigation of the physical conditions of the atmosphere and their relations to the forces of light, heat, electricity and magnetism. The practical form of meteorological research may be called the science of the weather and so treated. The weather embraces the changes which are from time to time taking place in the physical condition of the atmosphere and the effects produced by such changes. These effects find their expression in the temperature of the air, the direction and motion of the wind, the amount of moisture contained in the atmosphere, and the balancing of the antagonistic forces of evaporation and condensation, on which depend what is termed in common parlance, the fineness or the contrary of the weather.

The study of the weather has attracted much attention in the past fifteen years, owing to the development of telegraphy

and the facilities which are thereby afforded for examining the conditions of the atmosphere existing simultaneously at different places.

The earliest records of the weather among every nation are to be found in these myths of popular tales, which, while describing rain, cloud, wind, and other natural phenomena in highly figurative language, refer them to some supernatural or personal agency by way of explanation. At a later period the premonitory signs of good or bad weather became formulated into short sayings, or popular prognostics. A large number of these are still current in every part of the world, but their value is very questionable. About the commencement of this century, the science of probabilities came into existence, and developed the science of statistics. By this method the average readings of meteorological instruments at a number of places were calculated, and numerical values obtained for certain abstract quantities. But when the attempt was made to apply statistics to weather changes from day to day, it was found that average results were useless.

The mean temperature for any particular day of the year might be 50 degrees, if compiled from the records of a great many years, but in any particular year it may fall as low as 46 degrees or rise as high as 60 degrees. The first application of this average method was made by the great Napoleon, who directed Laplace to calculate when the cold of winter set in severely over Russia. The latter found, that on an average it did not set in hard until January. The Emperor made his plans accordingly; a sharp spell of cold came in December, and the army was lost.

Another case, somewhat similar and fresh in the mind of the public—the great flood at Johnstown, Penn. The dam at South Fork was built on the basis of a certain average and maximum rainfall for that section of the State. The values were roughly approximate, although calculated from long years of record. But the terrible results that followed hard upon the excessive rains of May, 1889, show the futility of predicting from average values. It is now quite well recognized that statistics give a numerical representation of climate, but little or none of weather, and that large masses of figures have been accumulated, to which it is difficult to attach any

physical significance. The misuse of statistics has done much to bring the science of meteorology into disrepute.

The advent of the weather map, made possible by the development of telegraphy, has changed the whole aspect of meteorological study. By this synoptic method, and the simultaneity of the observations at many points, covering a large extent of country, results are attained that simplify the movements and changes of the atmosphere, and make it possible for a person of fair intelligence to understand and make practical use of them. The study of the weather map will not only reveal the actual changes and probabilities attendant upon disturbances of large areas, but also afford the means of securing reliable knowledge concerning local indications. It is here that the farmer, mechanic and merchant can obtain information that will lead them to make their own forecasts. They can learn to watch and comprehend the development and progress of storm areas, and areas of cold air as they pass across the country. The map not only explains why certain prognostics are usually signs of good or bad weather, and the reasons why the indications sometimes fail, but also the reason why rain, for instance, is sometimes foretold by one prognostic and sometimes by a totally different one. Moreover, it not only gives greater meaning to all the statistics which partially represent the climate of a place, and the relation of diurnal to the general changes of the weather; but it also enables new inferences to be drawn, which had hitherto been impossible from some observations, and explains why other sets of figures must always remain without any physical significance.

The weather map opens the way to a practical and scientific knowledge of the weather, because it deals with the actual facts over an enormous extent of country, and places them in a position for accurate analysis and reliable comparative study. It is from this bird's-eye view, and faithful cartographical representation of the daily work of the atmosphere, that we must expect the solution of weather problems, both general and local.

LIST AND DESCRIPTION OF STEREOPTICON VIEWS EXHIBITED IN THIS LECTURE.

General Atmospheric Disturbances.

1. Outline meteorological map of the United States.
2. General circulation of the atmosphere.
3. Typical cyclonic circulation.
4. Typical anti-cyclonic circulation.
5. Vertical section of cyclone showing wind system.
6. An anti-cyclonic wave of barometric pressure.
7. Movement of ships in a cyclone at sea.
8. Paths of storm frequency in North America with distribution of rainfall.
9. Cyclonic storm tracks in the North Pacific.
10. Cyclonic storm tracks in the South Pacific.
11. Storm paths (Pacific Coast), dry season.
12. Storm paths (Pacific Coast), wet season.
13. Cyclonic storm tracks over the North Atlantic during June.
14. Tracks of West India hurricanes for over 100 years.
15. Tracks of hurricanes over the Gulf of Mexico for over 60 years.
16. Distribution of atmospheric pressure during blizzard of January 9, 1886. Wind velocity on Mount Washington N.W., 122 miles per hour; Block Island, 64 N.E.; Boston, 64 N.E.; Eastport, 60 N.E.; snow reported over 20 feet deep in many valleys throughout the Dakotas; all trains blockaded throughout the Northwest; heaviest snowfall in years; severe cold wave east of the 100th meridian; millions of dollars of damage to orange trees in Florida; cold norther in Texas, with high winds, snow and a fall in temperature of from 30 to 60 degrees in 24 hours; at Pensacola, Fla., bay frozen over from shore to shore; hundreds of fish paralyzed with cold; cattle frozen; Charleston, S. C., several persons frozen to death; Gainesville, Ga., 2 degrees below zero and in vicinity 7 below, ground frozen 18 to 20 inches; in Northwest, temperature fell 30 to over 50 degrees below zero; Fort Benton 51 degrees below zero.

17. Distribution of atmospheric pressure and movement of cyclonic storm giving rise to the Johnstown flood in Pennsylvania, May 30th to June 1st, 1889; heaviest rainfall in Pennsylvania, 8.37 inches on May 31st at Grampion Hills; reservoir at South Fork Dam, three miles long by two miles wide, depth 40 feet; all of the rainfall that fell in reservoir could only raise its surface five and three-tenths feet; rain lasted for 32 hours; loss of life, 5,000; loss of property, $25,000,000; money contributed, over $4,000,000.
18. Topographical relief map of California.
19. Cyclonic storm of February 22, 1891, on the Pacific Coast.
20. Distribution of atmospheric pressure over the Pacific Coast States during prevalence of hot norther in California on May 28, 1887: Keeler, 93.3; San Francisco, 96.9; Red Bluff, 103.5; Sacramento, 97.7; Willows, 112, Fort Gaston, 107; Oroville, 102, Eureka, 75; Los Angeles, 81.8; San Diego, 69.2; Yuma, 97.3.
21. Distribution of atmospheric pressure giving rise to a cold wave in the Pacific Coast States on December 11, 1891.
22. Distribution of atmospheric pressure over the Pacific Slope indicating the approach of a warm wave over Northern California.
23. Distribution of atmospheric pressure over the Pacific Coast States giving rise to a hot norther in Southern California on June 10, 1877: Los Angeles, 101 on the 8th, 103 on the 9th, 104 on the 10th, 112 on the 11th; Cajon Rancho, 107 on the 9th, 112 on the 10th; Holloways, 105 on the 11th; Spring Valley, 111 to 122 on the 11th; Campo, 101 on the 11th; Stanwix, 108 on the 11th; Yuma, 114 on the 12th; Stanwix, 110 on the 12th; Maricopa Wells, 110 on the 12th; Wickenburg, 108 on the 12th; Camp Verde, 104 on the 12th; Campo, Tucson, Phoenix and Florence, 100 on the 12th; San Francisco, 92 on the 11th; San Diego, 93 on the 9th.
24. Distribution of atmospheric pressure over the Pacific States giving rise to a cold wester in Northern California on May 9, 1887: Frosts in Northern California, Oregon and Western Nevada; snow in the mountains; heavy cloudiness in California, Nevada, Oregon and Washington; rain at scattering stations in Northern California;

Fort Apache, 41.5; Fort Bidwell, 24.2; Boise City, 40.8, 26 on the 11th; Eureka, 38.6; Helena, 37.5, 32 on the 11th; Keeler, 57, 40.5 on the 11th, 40 on the 12th; Los Angeles, 52; Portland, 36.9; Red Bluff, 42.5, 40.9 on the 11th; Roseburg, 33.4; Sacramento, 41; Salt Lake City, 56, 39 on the 11th; San Diego 60, Winnemucca, 31.8, 20 on the 11th, 16.8 on the 12th.

25. Distribution of atmospheric pressure over the Pacific Slope and Plateau Regions giving rise to the severe cold wave of Christmas night, 1891, in Southern California.
26. Distribution of atmospheric pressure giving rise to heavy fog along the coast of Northern California.
27. Movement of clouds and fog over the Coast Range from the ocean at an elevation of about 4,000 feet in the vicinity of Mt. Diablo.
28. Atmospheric circulation during the formation of a single cumulus cloud.
29. Atmospheric circulation during the formation of a mass of cumulus clouds.
30. Typical annual fluctuation of rainfall by months at various places in the United States.

LOCAL ATMOSPHERIC DISTURBANCES.

31. Geographical distribution of tornadoes over the United States for a period of 200 years.
32. Distribution and direction of tornado tracks in the Carolinas for about 100 years.
33. General atmospheric circulation indicating the approach of conditions favorable to the formation of tornadoes.
34. Local circulation of air in the tornado cloud.
35. Path of the great cyclonic storm of February 19th, 1884, with attendant tornado tracks.
36. Geographical distribution of the areas of warm and cold air during the tornadoes of February 19, 1884.
37. Distribution of barometric pressure over the eastern portion of the United States during the occurrence of the tornadoes of February 19, 1884.
38. Distribution of atmospheric pressure over the central

portion of the United States during the occurrence of the Louisville and other tornadoes on March 27, 1890.

39. General circulation of the atmosphere and weather changes over the United States during the occurrence of the Louisville tornado, March 27, 1890.

40. Incipient tornado clouds seen at Delphos, Saline Co., Kansas, on May 30, 1879.

41. Tornado cloud passing over Lake Winnepiseogee, N. H., on June 22, 1888.

42. Tornado cloud passing over Osage Co., Kansas, on June 12, 1881. Three persons killed, thirty wounded and fifty-three buildings destroyed. Loss $150,000.

43. Tornado cloud seen near Howard, Minor Co., South Dakotah, on August 28, 1884. Ten people killed and all property in the path of the storm destroyed.

44. Tornado cloud passing near Ercildoun, Penn., on July 1, 1877. Five people killed and sixty buildings destroyed; Loss $40,000; one hundred people wounded.

45. Tornado cloud at Delphos, Kas., showing its peculiar form when passing over the river, carrying up water and various kinds of debris.

46. Tornado cloud passing within about five miles of Garnett, Kansas, at 5.30 P.M. on April 26, 1884.

DESTRUCTIVE EFFECTS BY TORNADO CLOUDS.

47. Destruction of buildings at Brownsville, Saline Co., Missouri, on April 18, 1882.

48. Destruction of County Court House at Kansas City, Mo., May 11, 1886.

49. Terrible force of the wind at Rochester, Minn., August 21, 1883. Straws driven into fenceposts and trees.

50. Tornado in Morgan Co., Ill., on May 18, 1883. Three persons killed, twenty-five wounded. Cars blown from the track and destroyed. Railroad track torn up in several places.

51. Tornado at Connersville, Ind., May 14, 1883. Large iron bridge thrown from its piers and abutments into the river, a complete wreck.

No. 52. Tornado at Grinnell, Ia., June 17, 1892. Overturning by the wind of a freight train on the Iowa Central R. R.

52. Tornado at Grinnell, Iowa, June 17, 1882. Freight trains blown off the track and overturned.

53. Tornado at Lawrence, Mass., July 26, 1890. Red oak tree 14 inches in diameter broken off near the ground.

54. Lawrence tornado, showing great destruction. Dead horse.

55. Lawrence tornado. House bottom side up.

56. Lawrence tornado. Great destruction of buildings.

57. Lawrence tornado. Great destruction of residences.

58. Louisville tornado of March 27, 1890. Destruction of buildings.

59. Louisville tornado. Destruction of the depot of the Louisville and Nashville R. R.

60. Louisville tornado. Destruction of buildings.

61. Louisville tornado. Destruction of buildings.

62. Louisville tornado. Destruction of buildings.

63. Louisville tornado. Destruction of residences. Dr. Griffith's house.

64. Tornado at Grinnell, Iowa, June 17, 1882. Destruction of buildings.

65. Tornado at Jamestown, Ohio, April 27, 1884. School house destroyed. Ten killed. Loss of property, $200,000.

66. Jamestown tornado. Destruction of buildings.

67. Jamestown tornado. Destruction of buildings.

68. Tornado at Steelville, Ill., February 19, 1888. Large oak tree broken off near the ground.

69. The peculiar disposition of trees in piles, whirled down during the passage of a tornado cloud through a forest near Lee Summit, Mo., May 29, 1879.

No. 70. Tornado at Racine, Wis., May 18, 1881. School-house carried 500 yards by the force of the wind.

70. Tornado at Racine, Wis., May 18th, 1881. School-house carried 500 yards by the force of the wind.

71. An enormous tornado cloud, causing great destruction of life and property at New Ulm, Minn., June 10, 1881.

72. Heavy thunderstorm near Covington, Ohio, May 13, 1886. Horse killed by a bolt of lightning.

73. Tornado and water spout on Lake Erie, near Cleveland,

Ohio, June 5, 1864. Thunderstorm following the tornado cloud, with very heavy clouds, from which lightning flashes are constantly darting.

OTHER LOCAL STORMS.

74. Thunderstorm and lightning at sunset, Wakefield, Mass., July 29, 1887. Instantaneous photograph of the lightning's flash.

75. Thunderstorm and lightning on coast of Maine, July, 1883.

76. Thunderstorm and lightning in northern New York, June 23, 1888. Instantaneous photograph of the lightning's flash.

77. Waterspout at sea off the coast of Sicily, August, 1876.

78. Large dust whirl in British India. The dust storm comes on without warning from any direction. A low bank of dark clouds is seen on the horizon, which rapidly increases, and before the spectator is aware the storm bursts upon him, wrapping everything in midnight darkness. Violent gusts or squalls succeed each other at short intervals, gradually becoming weaker, and at the close of the storm a fall of rain generally takes place. The air is often highly electrical.

79. Dust whirls in British India.

80. Dust whirls in British India.

81. Whirling dust columns in New Mexico.

82. The Pampero of the Argentine Republic. The Pamperos are southwest squalls coming off the Pampas, or extensive plains of the Argentine Republic. They are usually followed by a thunderstorm and rain, with decided falls in temperature, as much as 35 degrees in six hours, and are attended with a peculiar form of cloud wreath. These clouds have been seen fifty miles in length, and sometimes three of them in succession, rushing forward with the regularity of battalions of soldiers. These clouds develope during the passage of a cyclonic storm eastward over the northern portion of the Republic. The clouds attending the storm are rolled into this peculiar wreath by the winds suddenly shifting from east through

the north to west and southwest. The upper wind currents come from the northwest, preceding, during and after the Pampero.

83. Cloud scene from the summit of the Himalayas.

84. Cyclone on the Virginia Coast off Cape Henry, March 22d, 1877; signal service station communicating with stranded steamer Pauzter, a Norwegian vessel, by means of the Internatioual Code of Signals.

85. New York harbor; display of storm signal flags from the U. S. Signal Station, on the roof of the Equitable Building.

86. U. S. Signal Service Station, summit of Pike's Peak, Colorado, 14,336 feet above sea level; continuously occupied by the signal service for a period of fourteen years; the highest meteorological station in the world.

No. 87. U. S. Signal Service Station for Meteorological work, on the summit of Mt. Washington, White Mountains, N. H., 6,286 feet above sea level.

87. U. S. Signal Service Station, summit of Mount Washington, N. H., 6,286 feet above sea level; still occupied by the weather bureau.

88. An interior view of the signal station on the summit of Mount Washington, showing instrument and the observer at work.

89. Central office building of the U. S. Weather Bureau Washington, D. C., showing location and number of

instruments on the roof of the building, together with the flags and signals used in indicating weather changes.

90. U. S. Signal Service Station at Fort Conger, Arctic region, lat. 81°, 44′ N., long. 64°, 45′ W., occupied by the expedition, under command of Lieut. A. W. Greely, for meteorological, magnetic and electrical observations.

91. U. S. Signal Service Station, Mount Whitney, Cal., occupied by Prof. S. P. Langley in 1881 for conducting special observations on solar radiation; elevation above sea level, 14,887 feet.

92. Meteorological and Magnetic Observatory, Japouski Island, Sitka harbor, Alaska; occupied by the Russians from 1842 to 1867.

93. Pressed-up floe berg, Breakwater Point, Lady Franklin Bay, Arctic regions, June, 1882; observed by the Greely Expedition.

94. Arctic Highlander from Cape York; photographed by the Greely Expedition.

95. Salton Lake, Colorado desert, southern California, showing the lake and also the salt-works.

96. Eaton Canyon, Mt. Wilson, southern California, showing clouds descending into the valleys from the crests of the San Bernardino range, with the downward flow of air currents in the afternoon.

97. The Government rain-making party near Fort Worth, Texas, August 12th to 14th, 1891, in the field, conducting experiments for the artificial production of rain by the use of high explosives fired from mortars on the ground, and from captive balloons at considerable heights in the air.

98. Rescue of Lieut. Greely and his companions at Cape Sabine, Smith Sound, lat. 78° N., long. 74° W., by the Government relief expedition, under the command of Capt. Schley of the navy.

THE DISCOVERY OF SAN DIEGO BAY.

GEORGE DAVIDSON.

The authorities for the following account of the discovery of San Diego Bay are Ulloa (1), Cabrillo (2), Ferrelo (3) and Vizcaìno (4). The descriptions are from my own examinations and drawings.

So soon as the explorers and soldiers of Cortes had reached the Pacific seaboard at three different points, enterprises were inaugurated (1527) to explore the coast to the northwestward, and to stretch across the Pacific Ocean to the East Indies, the goal of Columbus.

Exploration by land along the immediate shores of Mexico was impracticable, on account of the rugged character of the coast line; and therefore small vessels were built for the navigation to the northward. The outfit of these vessels in cordage, iron work, anchors and guns was carried from Vera Cruz, on the Gulf of Mexico. This enormous and unparalleled labor must be taken as a measure of the intense desire of Cortes to control the traffic of the Indies.

In these expeditions the Gulf of California was discovered, and in 1839 the expedition under command of the Magnifico Caballero Francesco de Ulloa essayed to follow the Pacific coast of the peninsula of Lower California, from Cape San Lucas to the northwestward. In the winter of 1539–40 Ulloa, with the Santa Agueda and La Trinidad, reached as high as El Cabo de Engaña (the present Point Baja) in latitude 29° 56′ north, about 165 nautical miles south of Point Loma at the entrance to San Diego Bay. In that undertaking he made many heroic attempts to work to the northward, but was always driven back by the strong northwest winds to seek shelter under Cerros Island (la Isla de los Cedros).

The next expedition was the voyage of exploration organized by the Viceroy don Antonio de Mendoza, who fitted out two vessels, and placed them under the command of Juan

Rodriguez Cabrillo, a Portuguese of great courage and honor, and a thoroughly competent seaman; the chief pilot and second in command was Bartolomè Ferrer or Ferrelo. These leaders had under them three Fathers of the Church, pilots, cosmographers, sailors and soldiers.

At high noon on the 27th of June, 1542, the expedition left the Port of Navidad, in latitude 19° 13′ N., and twenty-five miles from the Port of Manzanilla. The flagship was named the San Salvador, and placed under the command of Cabrillo; the second was named La Victoria, under the command of Ferrelo. When Cabrillo, died in the harbor of Posesion, at San Miguel Island, the westernmost of the Santa Barbara Islands, in January, 1543, Ferrelo took command of the flagship. We have no record who took Ferrelo's place.

For our present purpose it is not necessary to follow these poorly found vessels in their daily progress of discovery, trial and success. In the monograph, "An examination of some "of the early voyages of discovery and exploration on the "northwest coast of America from 1539 to 1603,"* they have received praise for their daring, courage, and perseverance; and every point of land, every bay and islet, every anchorage and harbor mentioned by them (seventy-one in number), has been identified and located.

On Thursday July 6, 1542, the fleet left Cape San Lucas, in latitude 22° 52′ north; on the 13th they passed the entrance to Magdalena Bay (El Puerto de San Pedro of Ferrelo). On Thursday the 10th of August they sailed from Cerros Island, of which the southern point is in latitude 28° 02′ north. This island was named Cedros by Ulloa, Zedros by Ferrelo, Cerros by Vizcaìno, and in 1734 Amalgua by Father Taraval. On Sunday the 20th of August they left the shelter of San Gerónimo Island (la Isla de San Bernardo of Ferrelo) in latitude 29° 48′ N.; on Tuesday, the 22d, they landed at Port San Quentin (El Puerto de la Posesion of Ferrelo), in latitude 30° 22′ N., and took possession of the country in the name of his majesty and of the most illustrious Señor Don Antonio de Mendoza.

On Saturday, the 23d of September, after taking possession of the country adjacent to their anchorage in Todos Santos

* Annual Report of the Superintendent of the United States Coast and Geodetic Survey for 1886. Quarto: pp. 155-253 and chart. Washington; Government Printing Office, 1887.

Bay (El Puerto de San Martin of Ferrelo), in latitude 31° 51′ N., they continued their voyage to the northward.

Approaching what is now the southern boundary of California, it will be proper to quote the narrative of Ferrelo, with full extracts from the subsequent narrative of Vizcaìno in 1602. The short and unsatisfactory narrative of Cabrillo in Herrera's "Historia General," gives not a word of description of the events and points of discovery between the 4th of September and the 10th of October, when, at the latter date, he was off San Buenaventura (Los Pueblos de las Canoas). It is, therefore, a curious fact that the discovery of the coast between Todos Santos Bay and the Canal of Santa Barbara, is related by the second in command at that date. Even Ferrelo's narrative is quite meagre.

THE CORONADOS ISLANDS.

When approaching the Coronados Islands, just south and in sight of San Diego, Ferrelo says:

"On the Tuesday and Wednesday following [the 26th and "27th of September], they sailed along the coast about eight "leagues, and passed by some three uninhabited islands. One "of them is larger than the others, and extends two entire "leagues, and forms a shelter from the west winds. They "are three leagues from the main land; they are in thirty-four "degrees. This day they saw on the land great signal "smokes. It is a good land in appearance, and there are "great valleys, and in the interior there are high sierras. "They call them Las Islas Desiertas."

Vizcaìno subsequently says: "After sailing a few leagues "[to the northward] the wind shifted to the northwest, but "we kept coasting along the shore, and were interested by the "smokes and fires made by the Indians all along the beach "as an invitation to send our people on shore. The country "appeared very beautiful, and level, and pleasant; at the dis-"tance of six leagues from the main land, we fell in with "four islands, to which we gave the name 'Los Coronados; "the two smaller appear like sugar-loaves; the other two "somewhat larger." He named this small group of islands in honor of Francisco Coronado, Governor of the Province of Xalisco under Cortes. On the chart he names them Las Islas

de San Martin, and places an anchorage on the north side of the largest.

In 1734 Cabrera Bueno, in his description of the coast, renames them the Island of San Martin, with some very small Farallones.

The Coronados, just south of the boundary between California and Mexico, and visible from San Diego, form a group of four or five rocky and desolate islets. A vessel coming from the southward recognizes them as the immediate landfalls for the Port of San Diego.

There are two main islets and three smaller masses of rocks. The largest islet is about seven miles from the coast line, and the others stretch to the northwestward for four or five miles. The largest is two miles long by half a mile wide; it is wedge-shaped, and at its highest peak attains an elevation of 674 feet. On the west and northwest sides lie two barren rocks fifty feet high. The northwestern islet is barren, seven-tenths of a mile in extent, and 350 feet high. A fair anchorage may be had in eight fathoms of water, over sandy bottom, on the east side of the islet, northward of its middle.

Kohl commits an egregious blunder when he says, that "there is little doubt that the 'Dolores' mentioned by Father "Taraval in 1734 were the Coronados Islands." As a matter of fact, Father Taraval was never north of Cerros Island.

From a vessel's deck, before being up with the Coronados Islands, the high land of Point Loma, forming the northwest side of the entrance to San Diego Bay, is in full view as an island.

Sometimes the early navigators utterly fail to record any notice of remarkable mountains as landfalls visible from their decks, such as Table Mountain, lying about ten miles inside the shore line, a little to the southward of the latitude of the Coronados. That mountain is a notable landfall to the navigator, but Cabrillo and Ferrelo are silent about it. Vizcaino called it the "Mesa de la Cena" (Table of the last Supper), and Vancouver mentions and gives a characteristic view of it. Its height above the sea is 2,244 feet, and it is visible at a distance of fifty miles from seaward. The flat top has a diameter of 1,600 yards.

In direct contrast with this flat-topped mountain are the

three sharp, jagged and higher peaks lying a few miles to the southeastward.

SAN DIEGO BAY.

El Puerto de San Miguel, latitude 34⅓°, Ferrelo, 1542.
El Puerto de San Diego, Vizcaìno, 1602.
El Puerto Bueno de San Diego, Vizcaìno's chart.
San Diego Bay, entrance in latitude 32° 40′ north.

The southern extremity of the isolated high ridge of land named Point Loma, forming the west side of the entrance to San Diego Bay, is in latitude 32° 39′ north. We have, therefore, a correction of 1° 40′ to the latitude of Ferrelo, or a little larger than the corrections which we have found for all his positions north of Cape San Lucas.

We now give Ferrelo's narrative, continued from the description of the Coronados:

"The Thursday following [being September 28th, 1542], "they proceeded about six leagues along a coast running "north-northwest and discovered a port, land-locked, and very "good, to which they gave the name of San Miguel. It is in "thirty-four and one-third degrees; and after anchoring in it "they went on shore, which had people, three of whom remained "and all the others fled. To these they gave some presents; "and they answered by signs that in the interior had passed "people like the Spaniards. They manifested much fear. This "same day at night they went on shore from the ships to fish "with a seine, and it appears that there were here some "Indians, and they began to discharge arrows and wounded "three men.

"The next day in the morning they entered farther within "the harbor, which is large, with the boat, and they brought "away two boys, who understood nothing by signs, and they "gave them both shirts, and immediately sent them away.

"And the following day, in the morning, there came to "the ship three full-grown Indians, and, by signs, they said "that there were traveling in the interior men like us, with "beards, and clothed and armed like those of the ships, and "they made signs that they carried cross-bows and swords, "and made gestures with the right arm, as if they were "throwing lances, and went running in a posture as if riding "on horseback; and made signs that they killed many of the

"native Indians, and for this they were afraid. This people "are well disposed and advanced; they go covered with the "skins of animals. Being in this port, there passed a very "great tempest, but on account of the harbor being good "they suffered nothing. It was a violent storm from the west-"southwest and south-southwest. This is the first storm "which they have experienced. They were in this port until "the following Tuesday. Here Christians are called "Guacamal.

"The following Tuesday, on the third day of the month of "October, they departed from this port of San Miguel, and "during Wednesday and Thursday and Friday they proceeded "on their course, about eighteen leagues along the coast, on "which they saw many valleys and much level ground, and "many large smokes, and, in the interior, mountains."

On the return voyage from the north the two vessels of Ferrelo were separated in a great storm, and each sought the other among the Santa Barbara Islands without success. After leaving this rendezvous the consort sailed directly to Cerros Island. Ferrelo sought the other vessel in San Diego Bay, and gives the following short memorandum:

"Sunday, the eleventh of the said month [of March, 1543], "they came near the Puerto de San Miguel; neither did they "find here their consort nor any news of her; here they "waited six days; here they took two boys to carry to New "Spain for interpreters, and left certain signals in case the "other ship should approach."

This description of the harbor of San Diego is so unsatisfying, the more especially as we have no record of any charts made by Cabrillo or Ferrelo, that it seems just and proper to introduce the narrative of Sebastian Vizcaìno, who must certainly have had the narratives and charts of his predecessors; and, further, because some interesting questions have arisen about an extensive forest which the narrative of Vizcaìno's voyage is supposed to locate on Point Loma.

It must be understood that all the immediate vicinity of San Diego Bay and of False Bay to the northwestward, is quite low country, with mountains well inland; and that the only high land near these bays is the long rocky ridge of Point Loma lying, in part, between them. This sandstone ridge is 457 feet high within a mile of its southern extremity, and runs

northward about five and a half miles with a breadth of one mile. The top of the ridge is of nearly uniform height, and the land at the northern extremity and beyond is quite low, so that the Loma is necessarily thrown into strong relief. In 1851 at our first visit it had very few small trees upon it, with plenty of cacti and chaparral. There never was a forest upon it, and the supposed forest upon it in 1602 arises from an erroneous translation of the words "el monte."

"To the north of these Islands [Los Coronados] in the "mainland is a famous harbor which was named El Puerto de "San Diego, which the squadron entered at seven in the even-"ing of San Martin, on the tenth of November [1602]. On "the day following the General ordered several persons to "survey a hill (el monte) which afforded protection to this "port from the northwest winds. This expedition was un-"dertaken by Ensign Ferez Alarcon, Captain Peguero, the "Carmelite Father Antonio de la Ascension, and eight sol-"diers. On this hill they found much wood of live oaks, and "other trees; some shrubs, resembling rosemary, and a great "variety of fragrant and wholesome plants. The summit of this "hill commanded a view of the whole harbor, which appeared "very great and very commodious, and well sheltered from "every wind. The hill which borders this harbor on the "northwest is about three leagues in length and half a league "in breadth; and to the northwest of this hill there is "another good harbor [El Buen Puerto]. On their return with "this report to the General he ordered a tent to be taken on "shore for religious worship, and that the ships should be "cleaned and tallowed; the people at the same time being "employed in wooding and keeping guard. They obtained "their water from a sandy beach, on a little island of sand "where they dug deep trenches, in which, during the flood "tide, the water was fresh and good, but on the ebb tide it "was salt. One day a sentinel, who was posted on the hill, "gave warning that he saw a great number of Indians coming "along the shore, naked, and their skins daubed with black "and white colors, and armed with bows and arrows. On "this the General desired Father Antonio de la Ascension to "go towards them and offer them peace. The Father was "attended by Ensign Juan Francisco and six soldiers. On "coming up to the Indians, having made signs of peace with

"a piece of white linen, and throwing earth upon their hands, "the savages immediately delivered their bows and arrows to "the soldiers. Father Antonio embraced them and gave them "bread and necklaces, with which they were greatly pleased; "but on coming to the General's quarters the Indians, at the "sight of such a number of people, drew back to a litttle emi-"nence, from whence they sent two women, who, approaching "the General's tent with a timid air, the Fathers and others "made them presents of beads, biscuits and strings of bugles; "and then dismissed them to give their countrymen an ac-"count of the usage they had met with from the strangers. "Their report was doubtless very favorable, for soon after the "Indians all came with them to see the Spaniards. Most of "them were painted or besmeared with black and white, and "their heads covered with feathers. The General and the "others received them with extreme courtesy, and distributed "among them several things and a great deal of fish which "had been caught with the seine in their presence. The kind "of paint they used looked like a mixture of silver and blue "color, and on asking them by signs what it was they gave "us a piece of metallic ore, from which they had made it; and "they signified by signs that a certain people of the country "who had beards and were clothed like the Spaniards, made "from this mineral very fine ribbons, resembling the laces on "the soldiers' buff coats, and some like that on a purple velvet "doublet, in which the General was then dressed, adding that "these men, by their dress, complexions and customs, seemed "to be of the same country with ourselves. The Indians "were quite transported with the good treatment shown them, "and every third day they came for biscuit and fish, bring-"ing with them skins of several kinds of beasts, as sables, "wild cats, and the nets with which they catch them.

"In this harbor there is a great variety of fish, as oysters, "mussels, lobsters, soles, sardines, &c., and in some of the "esteros, which make into the land, were found geese, ducks, "&c.; and quails, rabbits and hares were also found in great "numbers. The General and Father Antonio being desirous "of viewing the country took with them some soldiers, and "walked a considerable distance from the coast, and were "highly delighted with the mildness of the climate and the "goodness of the soil.

"Everything being finished according to the General's "orders, the squadron left this place on the 20th of Novem- "ber [1602], but many of the soldiers were sickly, and some "very valuable persons had died while they continued in this "harbor.

"They had no sooner left San Diego Bay than they met "with their common difficulty, a strong northwest wind. "Little by little, however, the ships advanced and came in "sight of a gulf where the neighboring country presented a "very pleasant appearance. And as they proceeded they saw "at every point the smoke of large fires which the Indians "had kindled to induce the ships to put in there. But on "closely approaching the coast the ships found no shelter "from the northwest wind, and therefore continued their "course; and a few leagues farther they discovered a large "island about twelve leagues from the coast, and from the "day of its discovery de la gloriosa Martyr Santa Catalina, "they named it the Island of Santa Catalina."

When Vizcaìno's vessels returned from their expedition, late in January, 1603, the crews had been nearly cut off by scurvy; all were badly affected, and only two or three were strong enough to do duty. The ambitious General was, therefore, compelled to pass this and other ports and sail directly home.

This is all we know of San Diego Bay for one hundred and sixty-six years, up to the time of Portolá's expedition of 1769; and from that one we need not quote.

We may, however, give a short general physical description of the bay without referring to its population, agriculture and horticulture, its towns, railroads, wharves and commerce.

In this we quote from the *Pacific Coast Pilot* of 1889:*

Next to that of San Francisco no harbor on the Pacific Coast of the United States approaches in excellence the Bay of San Diego. To the southward are the great landfalls of Table Mountain and the Three Sharp Peaks; and the secondary landfall of the Coronados Islands. And from either the southwest or northwest the location is readily distinguished by the notable landmark of Point Loma, whose southern point is in latitude 32° 39′

* Coast Pilot of California, Oregon and Washington; George Davidson, assistant, United States Coast and Geodetic Survey. Fourth edition (entirely re-written). Washington: Government Printing Office, 1889. Quarto: 721 pp., 1 chart, 464 views.

north. Vessels approaching San Diego Bay make the ridge of Point Loma as a long, flat-topped Island when about twenty-five miles distant. It is clearly in view before a vessel is up with Los Coronados, when the main land is not yet seen. This general appearance of the high ridge being an island is occasioned by the bay to the southeast, by the low land to the northeast, and by the Puerto Falso and adjacent low land to the north and northwest.

The entrance to the Bay of San Diego lies under the southeast side of Point Loma, about two miles inside the extremity of the Point. It is easily approached on account of the absence of outlying dangers, and is marked by a great field of kelp to the southwest, and by great buoys leading across the bar. Just outside the narrow entrance to the bay is a bar having twenty feet of water upon it at low water; but on account of the absence of heavy seas in this low latitude, and the protection of the great kelp field, and the projection of Point Loma outside the bar, the bar may be safely passed at all times. In forty-two years there are only two or three reports of the swell breaking upon the bar during the southeast storms of winter.

The bay itself is a long curving body of water about twelve miles in length and from one-half to two miles in width. For the first six or seven miles from the entrance there is a fine broad channel, carrying four to eight fathoms of water The southern part of the bay is occupied by extensive flats, through which a channel with twenty to twelve feet of water is formed. Between the southern part of the bay and the ocean lies a very narrow strip of low dunes. Near the entrance this expands into a broad and extensive area, which presses close upon and borders the channel abreast of Ballast Point. Upon the southern part of this area, which was formerly known as "The Island" and the "Peninsula," is now the town of Coronado, with its magnificent Coronado Hotel.

Inside the entrance the old anchorage place was off "La Playa," now oocupied by the United States. Here, and farther inside, the land-locked bay can afford protection for great fleets.

Although the history of San Diego has been clear and unquestioned from its first discovery, Kohl blunders very badly

indeed when he says that Father Taraval's "Bahia de San Xavier" is probably the small bay now known as "San Diego Harbor." I have elsewhere shown that Father Taraval was never north of the Cerros Island, and that his Bay of San Xavier is the great gulf lying eastward of Cerros Island, and known on the present charts as the Bay of Sebastian Vizcaino.

GEORGE DAVIDSON.

San Francisco, September 7, 1892.

"Recent Visual and Photographic Astronomy."

BY PROF. E. E. BARNARD.

The distinguished observer was introduced by the President of the Society as the discoverer of the Fifth Satellite of Jupiter, but whose modesty would certainly prevent his referring to discoveries made by himself.

Professor Barnard then began his lecture with a condensed account of the progress of photography as appl ed to astronomy.

In the earlier days of the photographic art, but little progress was made in its application to the work of astronomy, but the introduction of the wet, or collodion process, had much increased the value of photography for pictorial representation. There were, however, several very serious drawbacks to its application to the photography of the fainter celestial bodies. It gave most excellent results where the brightness of the object was such as to permit a rather brief exposure, such as the sun, the moon and the brighter stars. Remarkable photographs of the moon were obtained with this method by Rutherford, in 1864, and these pictures have scarcely been excelled up to the present time. In many respects this older method is still superior for lunar work. When it came, however, to photographing the nebulæ, the comets and the fainter stars, where the exposure must necessarily be prolonged for upward of an hour, the wet plate method was impracticable; the plates were not very sensitive, and a faint object made but slight impression upon them. Throughout the entire progress of exposure, etc., the plates must be kept wet. Under certain conditions they might be kept wet for perhaps half an hour, but if exposed much longer than this they were worthless. Dr. Gould, at Cordobá, was enabled to considerably prolong the exposure for stellar work by causing a stream of water to flow over the plate, but this necessarily caused a deterioration of the resulting negative.

In 1878, Professor Newcomb, at the total eclipse of that

year, had attributed the failure of the *sun* to impress itself on his plates to "the generally treacherous character of the dry plate method," and this expression of opinion showed what little hope was held out by this method, only a few years ago.

About 1882, the dry process had been so far perfected that its application to astronomy was merely a matter of trial. It seems the great comet of 1882 was the first incentive to place stellar photography on its present magnificent footing. Dr. Gill secured a photograph of this comet, at the Cape of Good Hope, with a dry plate and one hour's exposure. The remarkable abundance of stars depicted along with the image of the comet, in this short time, showed the latent power in the photographic method as an instrument for astronomical research.

The dry plate has now become a marvelous power in the hands of astronomers. It is vastly more sensitive than the old wet plate, and will keep for any length of time, so that the exposure may be indefinitely prolonged. It is so sensitive, indeed, that a cannon ball can readily be photographed in its flight. Combining this extreme sensitiveness with long exposure, it has been possible to photograph celestial objects which are so faint that their light fails utterly to make the feeblest impression on the human eye.

To day this wonderful photography is used in registering the exact appearances of the heavenly bodies, for comparison in times to come. With it the entire heavens are being charted, and millions of stars are accurately registered.

The astronomer Wolf spent four years of labor at Paris in measuring the stars of the Pleiades. When he had finished this work, he declared that he believed he had fathomed space in that direction, and had measured every star in that group. His chart showed 671 stars, and might be considered a lifework for one astronomer. In 1883 the Henry Brothers, of Paris, photographed the cluster. With one hour's exposure, they secured the impression of 1,420 stars, in the same space which Wolf had declared contained no more stars than he had observed, and with four hours' exposure the plate exhibited 2,326 stars. Thus in four hours' time the photographic plate had more than tripled the four year's work of a clever observer. Not only did these photographs reveal the unex-

plored richness of this region of the stars, but they surprised the astronomical world by showing that each one of the bright stars of the Pleiades was bound up and entangled in masses of nebulosity with its neighbor.

In the photography of the nebulæ, these remarkable objects are for the first time seen in their true shapes, and in a comparatively few years it will teach us more about the constitution and changes, and the laws that govern the nebulæ, than all the centuries of guess work and drawings that have gone before.

It is only by the application of photography that the Milky Way—a heretofore sealed book—is for the first time opened up to us, and its true character shown. The great star-clouds, and the wonderful dark or starless regions, are for the first time laid before us in all their intricate complexity. The study of these, and other pictures of the milky way yet to be made, will tell us more of the structure and mysteries of the universe than the ordinary method of observation could ever show.

By the aid of photography, new discoveries are constantly being made. The presence of an unknown comet is first heralded by its trail on the subtle photographic plate. The marvelous changes that the wandering comets undergo are also for the first time accurately and authentically recorded. The distances of the fixed stars are now determined by photography, with an accuracy not heretofore attained by ordinary methods of observation. The moon, whose tantalizing mysteries have ever baffled man, will some day tell us its history by the aid of photography.

The vagrant comets of space have told us of an unknown planet, away beyond Neptune, and some day the photographic plate will reveal to us its presence.

The application of photography to the spectroscope, in the study of the motion of the heavenly bodies, has revealed to us velocities and combinations of velocities not dreamed of before, some indeed so complex as almost to defy the laws of mechanics.

Perhaps it may be possible in a public lecture to explain how some of these wonderful spectroscopic discoveries have been made.

It is well known that when the light of the sun, or of any of the celestial bodies, passes through a prism, a brilliant band of exquisite colors, violet at one end and red at the other, is the result. This is called a spectrum. Across this, perpendicular to its length, is a system of black lines. The investigations of astronomers have shown that these lines are due to the presence of certain substances in combustion in the source of light. In the sun, and most of the stars, the lines are dark. The spectrum of a glowing gas, however, consists of bright light lines, while that of an incandescent body is simply a continuous band of prismatic colors without any lines. If an incandescent body be placed behind a gaseous substance, and its light be permitted to shine through the gas, all the bright lines of the gaseous spectrum will become dark, and will show black on the continuous spectrum of the incandescent body. Astronomers thus know that the stars are incandescent bodies, surrounded by dense absorbing gaseous envelopes.

By laboratory experiments, it has been possible to explain what these lines in the spectrum mean. It has been found that most of them can be reproduced exactly, by examining the spectrum of known substances here on the earth, in a state of combustion. Hence, by examining the spectrum, say of glowing hydrogen, we notice lines that correspond absolutely with certain dark lines in the spectrum of the sun and stars. It is therefore inferred, that the lines in both cases are due to hydrogen. The same is found to hold true for the spectrum of sodium, iron, etc., and thus we learn of the presence in the sun and the stars of nearly all the elements that go to make up our earth; but in the sun and stars these are in a state of vapor, on account of the extreme heat to which they are subjected. These lines not only tell us of the physical condition of the celestial bodies, but they also reveal to us their motions.

Previous to the application of the spectroscope to astronomical study, it was only possible to detect motion in the distant stars by accurately measuring their positions on the vault of heaven, at intervals of many years, and thus, from the resulting minute displacement of these bodies, to be able to say that they were flying through space with velocities infinitely

greater than that of the fastest express train. But we could not measure whatever motion they had toward or from us—in the line of sight—for this motion caused no measurable or apparent displacement on the sky. The spectroscope, however, while it does not take into account a lateral motion, or one perpendicular to the line of sight, reveals any motion that may exist to or from us, or *in* the line of sight

To make clear how this is possible, a familiar illustration may not be amiss.

It is known that the pitch of a musical note is due to the number of sound vibrations that occur in a certain period, say a second of time. The more rapid the vibrations, the higher the note. Let us take for example the familiar illustration of the locomotive whistle. When stationary, the whistle will give a certain note, due to the number of sound vibrations it makes in a single second. Now, if the engine should approach us, we shall receive a greater number of sound vibrations in the same interval, and the note must then be higher. If the engine recede from us, a less number of vibrations will reach us, and the note will be lower. If we were familiar with the note of this whistle when it was stationary, we could at once tell whether it were approaching or receding, simply by the pitch of its note. To make this clear, it is only necessary to call attention to the suddenness with which the note of the whistle drops its pitch as the engine rushes by us. Now, if we could accurately determine the note given out by the moving whistle, it would readily be possible to tell, not only which way it was going, but also just how fast it was moving, for sound travels at a known rate, and there is a constant relation between the velocity of sound and the change of pitch.

Returning now to the spectrum. The positions of the peculiar lines already mentioned in the spectra of the heavenly bodies are fixed by the laws of light—their exact position being due to the number of vibrations the molecules of the burning substance have imparted to the ether in a given time. A position towards the violet end of the spectrum indicates a more rapid vibration, or a greater number of light waves, say, in a second of time.

Suppose now the source of light is approaching us with a velocity anyway comparable with that of light itself. We

shall then get a greater number of light waves per second than if the body were stationary. All these lines will therefore be shifted towards the violet—just as the pitch of the note was higher when the engine approached us.

Now if at the time the spectrum of the star is examined, it is possible to produce beside it, for comparison, the spectrum of stationary hydrogen, or of some other substance whose lines are strongly marked in the spectrum of the star, we would find that either the hydrogen lines of the star coincide with those of our comparison spectrum, or they would be displaced to one side or the other. If there is a coincidence, it shows there is no motion of the star in the line of sight. If, however, the lines are shifted towards the violet end of the spectrum, the star is approaching us; if towards the red, it is receding. There is a relation between the amount of this displacement and the motion of the star, and hence by measuring the displacement, which can be accurately done, the amount of motion or velocity is known. Hence we can not only tell which way the star is moving in the line of sight, but we can also tell just how fast that movement is.

It is found that by photographing this spectrum, measures of the lines can be very accurately made.

The study of this beautiful phenomenon has led very recently to some most extraordinary discoveries in stellar motions.

Among the stars that appear single to the naked eye, and in small telescopes, there are many which the application of a powerful telescope will show to consist of two stars. These are called double stars.

In many cases these double stars are found to be revolving about each other—obeying the laws of gravity just as do our sun and its planets.

Professor S. W. Burnham, recently astronomer at the Lick Observatory, has made a special study of these double stars, and stands peerless as an original discoverer and investigator in this most important branch of astronomy. His remarkable powers of observation, combined with a wonderful keenness of vision, have revealed some of the most wonderful of these stellar systems. These great revolving suns require many years to complete their revolutions, and the most of them take

centuries to accomplish their periods. The closer these stars are together, in general, the shorter are their periods. Professor Burnham has discovered one of these stars with the remarkably short period of 11 3-10 years. It is known as *Kappa Pegasi.* Here we have two mighty suns revolving around each other actually in less time than the planet Jupiter takes to revolve about our sun. The shortness of the period of Kappa Pegasi was considered remarkable indeed.

In the course of his work at the Lick Observatory, Professor Burnham has been able to see and measure two stars, whose distance apart is but slightly greater than 1-10 of a second of arc, and this may be taken as the limit of the great telescope.

Having thus stated a few facts concerning the visual binary stars, *i. e.*, those double stars whose components can be seen with a telescope, we will try and show how another class of binary stars has been found—the components of which are so close together that no telescope will ever show them individually. They are called "Spectroscopic Doubles." Professor Pickering, in this country, and Dr. Vogel, in Germany, have been systematically photographing the spectra of the stars.

An examination of the different photographs of the spectrum of the star Zeta Ursæ Majoris, in the handle of the "Great Dipper," by Miss Maury, of the Harvard College Observatory, led to the singular discovery that the spectral lines in this star were sometimes distinctly double. A further investigation showed this phenomenon to be of a periodic nature. It was therefore possible to predict when the lines would be double or single.

There was but one satisfactory explanation of this peculiarity. The star must in reality consist of two bodies, rapidly revolving about each other in orbits whose planes lay nearly in the plane of vision.

We have spoken of the fact, that when the source of light is approaching us, the lines of the spectrum are displaced towards the violet. Suppose now there are two sources of light very close together—so close that they shine as one. There will be a spectrum produced by each object, and they will be superposed—one exactly fitting over the other. If these two bodies are in orbital motion about each other, during part of the time one of them will be approaching us and the other

will be receding. The lines in the spectrnm of the approaching body will be displaced from the normal towards the violet, and those from the receding body will shift to the red end of the spectrum. Hence the lines of the two spectra will no longer coïncide, but will appear separate, and each line will be double. At another point of their motions, the two bodies must be moving perpendicularly to the line of sight, the two sets of lines will again coïncide, and the lines will once more appear single, for there will then be no motion in the line of sight.

In the case of Zeta Ursæ Majoris, it was found that the periodic doubling had a maximum every fifty-two days, and hence the component suns must have a period twice this interval—or one hundred and four days! If we know the motion of an object in its orbit, and its period of revolution, we can determine the dimensions of the orbit, and the masses of the gravitating bodies. It was thus found that this star—apparently single in all telescopes—was in reality a double sun, the components of which were revolving about each other in one hundred and four days, at a natural distance of 143,000,000 miles; about the distance between Mars and our sun. The mass of each of these suns would be about twenty times as great as that of our sun.

Another star, with a still more remarkable period, was found at the same observatory. This was *Beta Aurigæ*. The lines in its spectrum were found to double every two days, and hence it consists of two suns whirling about each other in only four days! The velocities indicated by the measures are 150 miles a second. And the distance between the two stars is only 6,000,000 miles, or about 1-16 the distance between the earth and the sun. Knowing the distance between the two stars, and assuming a reasonable distance from the earth, it is possible to figure out the size of a telescope which would be capable of showing the individual stars that go to make up the star Beta Aurigæ. Such a telescope must need be nearly one hundred feet in diameter, or one thousand times more powerful than the great Lick refractor. Doubtless no such instrument will ever be built and successfully used by man. The telescope that was used in photographing the spectrum of the star, and which easily showed the lines double,

was only 1-25 as powerful as the Lick telescope. It will be seen from this that the spectroscope, aided by photography in this particular case, increased the power of the telescope at least twenty-five thousand fold!

The variable star Algol, in the head of Medusa, passes through a periodic variation in its brightness. Remaining fixed in its light for over two days, it begins to decline through a period of about four hours—until it has attained a brightness about one magnitude less than the normal. During the next four or five hours, it is regaining this lost light. These singular variations were discovered about two hundred years ago, by Goodrich. Among other explanations of this phenomenon, it was long ago suggested, that a large dark body might be revolving about the brighter star, and eclipsing its light at regular intervals.

Dr. Vogel, in photographing the spectrum of Algol, found no doubling of the lines, as in the case of the other stars, but he did find that the lines alternately shifted from right to left of their normal position in a period less than three days. Could this phenomenon indicate the presence of two bodies?

It showed that Algol, during one part of the short period, was approaching us, and at another was receding. There cou :d bbut one solution to this problem. Algol was revolving about a common center of gravity between it and another body—the presence of which was demanded by the laws of mechanics. The absence of any doubling of the spectral lines showed the presence of only one spectrum—that is, the second star did not give any light to produce a spectrum. It was, therefore, a dark or non-luminous body. This then is the true explanation of the variable light of Algol. The dark sun, in revolving about the bright one, comes between us and Algol at regular intervals, and intercepts or partially eclipses its light. Thus the mechanical theory, previously suggested as an explanation of the phenomena of this variable star, is confirmed.

The history and peculiarities of the new star in Auriga were discussed, and the statement made, that this object had become transformed into a nebula. Instead of the slow transformation, through many ages, of the nebula into a star, according to

the nebular theory, astronomers had watched the transformation of a star into a nebula in a period of less than four months' time.

This first portion of the lecture was illustrated with diagrams and colored charts of the solar spectrum.

The lights were then turned down, and a series of celestial photographs were projected on the screen by a powerful lantern.

The pictures consisted of photographs of the doubling of the spectral lines; the sun, the planets, the moon, the stars, and the milky way, the nebulæ and the comets—there being about sixty slides in all, which very thoroughly covered the entire field of celestial photography.

The lecturer very vividly described these beautiful pictures. Of great interest was one slide of an instantaneous photograph of a projectile fired from a Zalinksy pneumatic gun. This showed how extremely sensitive the photographic plate had now been made, yet so faint were some of the celestial objects photographed, that these same plates required upward of ten or twelve hours' exposure to receive visible impressions.

The Lalande Prize was established in 1802 by Lalande, the famous French astronomer. It is esteemed one of the highest honors an astronomer can receive. It was awarded to Prof. Barnard, at the meeting of the Academy of Sciences, December 19, 1892. It had previously been given to but four American astronomers; and to no one in 1891.

The Eruption of the Volcano Weniaminof.

PENINSULA OF ALASKA.

In the latter part of August, 1892, a great volcanic eruption occurred on the peninsula of Alaska, where very little is known of the geography except the ragged coast line, and the summit outline of the mountain mass behind it, as seen from the southward. Published references to the locality, about latitude 56°, and longitude 159° west, are very limited. We know from Tebenkof's charts that in the peninsula, in this region, where it is about forty miles wide, there are two large lakes hidden among the mountains; that they are connected by a small stream, and that the smaller lake, to the west-southwest, drains into the Pacific waters at Ivanof bay, and the northeastern and larger lake drains into the Bering sea at the native settlement of Meshik, near the Seal Islands. Bishop Weniamínof has only this remark*: "From the harbor of Kuprianof, that part of Alaska lying farther to the east does not belong to the fourth district; and from the journals of Worrokofski, beyond a few soundings and noting down here and there a few rivers, there are seemingly no topographical descriptions. But from the saying of the Aleutes, it is known that beyond or behind Cape Ivanof on the Alaska Peninsula, from the middle of a great back-bone of mountains, there issues smoke in large columns." Vol. 1., pp. 231-232.

Tebenkof, on page 61†, evidently repeats Weniamínof with variations: "From here to the northeastward, the mountains do not appear to stand forth in the same grandeur, and retreat farther from the coast of the Bering sea, but show in the interior of the peninsula their volcanic character, and there is, according to the accounts of the natives, between 158° and 159° long. west of Greenwich, and 56°

*Weniamínof's Description of the Unalaska Districts; 3 vols. 8vo. St Petersburg, 1840.

†Orographical and Geological Description of the North West coast of America and the adjacent islands, by Dr. C. Grewingk. 1 vol. 8vo., with charts. St. Petersburg, 1850.

lat., a place where, from the middle of a mighty mountain ridge, a thick pillar of smoke rises. Concerning this part of the northeast coast, and the interior of the peninsula, there are no accurate accounts, and we know only that northeast from Cape Ajuchta there lies mountainous country, and hear then of the Mt. Tschiginagak, and a coast, rich in glaciers, which stretches even to Mt. Alai." In a foot note, he says of the smoking mountain, that he has named the volcano Weniamínow; and in his second chart has located it in lat. 56° 05′, long. 159°. On page 211 he refers to the volcanic activity along the Aleutian chain, in 1838, when Schischaldin threw out flames, and Makúshin, Akutan, Pavlof and Weniamínof were smoking. On page 204 he quotes Bishop Weniamínof as authority for this volcano's smoking between 1830 and 1840.

This is all we can collect of the position and description of the Volcano Weniamínof, and it is, therefore, of interest to gather all the particulars of the recent eruption from those who were in the vicinity. From Captain Erskine, commanding the Alaska Commercial Company's steamer St. Paul, we learn that on Sunday, the 28th of August, 1892, when in latitude 53° 05′, longitude 155° 52′ west, on his voyage to the Shumagin Islands, he passed through a black cloud of volcanic ash, so thick that it very nearly obscured the sun from 10 o'clock A. M. to 2 o'clock P. M.; the sea was grey with the fallen ashes, and his decks were covered during his passage of thirty-two miles through it. It had a strong sulphurous odor. He noted the times when the vessel met the cloud of ashes and when it was passed. We have plotted this transit on the accompanying sketch, which is drawn from the chart of the U. S. Coast and Geodetic Survey. At noon the vessel was 223 nautical miles southeastward of the volcano; the wind was moderately light from the northwest, and the sea smooth. He estimated the cloud, as he saw it, to be about one hundred miles long, and from one-half to one mile high. He has furnished us with a bottle of the fine, dark grey dust, as it was gathered from the vessel's deck.

Lieut. John C. Cantwell, of the U. S. revenue steamer Richard Rush, has given us the following memoranda, which he obtained from Captain Applegate, who has been many years in Alaskan waters, and whose vessel was, at the time of the eruption, anchored in the harbor of Ivanof.

On Saturday, August 27, 1892, the schooner Everett Hays, engaged in hunting in the vicinity of the Shumagin Islands, entered Ivanof Harbor, on the southwestern extremity of the Alaska Peninsula, and only 25 miles southwestwardly from the volcano. Capt. J. S. Applegate, the owner, was on board, and states: "About 10 o'clock Saturday night, the weather being calm and clear, a low, rumbling, intermittent sound was heard, and caused the crew to come on deck to ascertain the cause. There was no surf, and the cause was unknown. Between 11 and 12 o'clock, a dark cloud was observed in the sky, towards the northeast, and about 2 o'clock, A. M., this cloud had increased in volume and height until it covered the greater part of the northeast heavens.

"The low, rumbling noise had become a continuous roar, like the blast from a great furnace, and by 3 o'clock lurid flames could be seen amidst the smoke, which was now rising high in tremendous volumes from a single point, being by compass about northeast. The vast column of smoke reached an estimated height of two miles, and then expanded like a great spreading oak. From the lower edge of this great volume, colored flames waved like banners, and vivid flashes of lightning were apparently discharged into the base of the column. This grand display continued, until daylight caused the flames to be somewhat dimmed, but masses of dense smoke continued to roll upward all Sunday. Toward noon a light northwest wind sprang up, and the clouds began to trend to the southeastward, covering the mainland and the adjacent islands with a thick layer of ashes and volcanic dust.

"At the anchorage it was dead calm, and there was no perceptible movement of the sea on the beach, as would have occurred had there been earthquake waves. The continuous lightning discharges were accompanied by deafening peals of thunder, that were plainly heard at the Metrufan village, 50 miles distant, and at Unga Island, 75 nautical miles distant."

Captain Applegate could not get the exact location of the volcano, on account of the high range of mountains, which here approach the sea. The Hays left Ivanof Bay on Sunday, and steered south to Pavlof Island, whence the ash cloud was plainly visible to the eastward until late on Monday, when it gradually disappeared in the southeast.

Captain Bowles, of the fishing schooner Fremont, of San Francisco, reports that on Saturday, August 27th, and for seven days after, he was lying at anchor on Slime Bank, in the Bering Sea, in the vicinity of Port Moller, and 60 miles nearly west from the volcano. He observed at the first date what appeared to be a heavy black cloud in the southeast, which he thought foreboded a southeast storm, and took precautions to put his vessel out of its track. On Sunday morning before daybreak, however, he and his crew saw volumes of ruby red and yellow flames bursting forth with indescribable grandeur from the cloud, and heard plainly the reverberations of thunder. The display lasted with unabated energy until Monday morning, when it appeared to die slowly away.

The general character of the volcanic dust has been kindly given to me by Mr. Henry G. Hanks, of the San Francisco Microscopical Society. Color, dark brown; magnetic; before the blowpipe, fuses easily to a glossy black globule, which is magnetic; gives strong iron reaction; heated in a glass tube, gives water and a faint white sublimate, otherwise no change.

Examined microscopically, the particles were found to be very minute, ranging from 0.005 to 0.00025 inch, with every grade between these extremes. All the particles were sharply angular, as if recently crushed. The larger part resembles nearly transparent quartz, the remainder contains a green mineral resembling several varieties of hornblende.

A qualitative analysis shows the presence of silica, oxide of iron, lime, alumina, water. Substances present in small quantities were disregarded.

GEORGE DAVIDSON.

CABLE SURVEYS

FROM CALIFORNIA TO THE HAWAIIAN ISLANDS.

1891-92.

BY LIEUT. COMMANDER Z. L. TANNER, U. S. NAVY.

The recently completed survey for a sub-marine telegraph cable between the California coast and the Sandwich Islands, forms the subject of this paper. Three routes were examined; two by the U. S. Fish Commission steamer "Albatross," and one by the U. S. S. "Thetis," Commander George C. Reiter, U. S. Navy.

I shall first take the liberty of briefly sketching the rise and wonderful progress of sub-marine telegraphy; referring also, in a general way, to the several reconnoissances, over widely divergent routes, which led up to the present survey for a Pacific telegraph cable.

The extensive and exceedingly interesting work of the U. S. S. "Tuscarora" under Captain, now Rear-Admiral, Belknap, U. S. Navy, occupies a prominent place in this paper, for which I offer no apology. I was greatly tempted to quote even more largely from the Admiral's entertaining and instructive papers.

Sub-marine telegraphy may be said to date from 1839, when, near Calcutta, a single wire about one and a quarter miles long was submerged and used in connection with a telegraph line 21 miles in length. The wire was insulated by a covering of cotton thread saturated with pitch and tar.

Several more or less successful attempts of this description were made from this time on over short distances, and in moderate depths. The first sub-marine cable, 21 miles in length, was laid in 1850 between Dover and Calais, in depths not exceeding 30 fathoms. The life of this pioneer cable was numbered by hours, but during its short existence messages were successfully transmitted, thus demonstrating the practicability of the system. A second and entirely successful cable was laid over the same route the following year.

Four lines were established in 1852, and an equal number in 1853. The cable between England and Holland is 115 miles in length, with a maximum depth of 24 fathoms, while a line from Scotland to Ireland, 25 miles long, reached a depth of 160 fathoms.

In 1854 seven lines were established; that from Italy to Corsica being 110 miles in length, with a depth of 325 fathoms. Nine lines were laid in 1855, aggregating over one thousand miles in length, the most important one being that from Sardinia to Africa, 160 miles, reaching the unprecedented depth of 1,500 fathoms.

The sub-marine telegraph was still in its infancy and subject to many failures; so many, in fact, that some of its advocates became discouraged, while others were financially ruined; yet progress was steady and rapid in spite of all obstacles.

In 1856, the longest line yet attempted was established between Crete and Alexandria, 350 miles, the greatest depth being 1,350 fathoms. The following year saw two lines of 500 miles each and 1,000 fathoms depth laid, from Sardinia to Malta, and from Corfu to Malta. But the greatest triumph in sub-marine telegraphy was attained in 1858, when the Atlantic cable was successfully laid from Ireland to Newfoundland. Many of us recollect that memorable event, and the universal and sincere rejoicings on both sides of the great ocean upon the successful transmission of the first message. Sub-marine telegraphy was no longer an experiment.

Although progress was exceedingly rapid from this time, nothing approaching the magnitude of the Atlantic cable was attempted until 1866, when two additional lines were laid from Ireland to Newfoundland, 1852 and 1896 miles in length respectively. The maximum depth was 2424 fathoms.

The next notable advance was the French cable from Brest, France, to St. Pierre, laid in 1869, 2584 miles in length, and 2760 fathoms, greatest depth. It was successful from the first, and remains to-day one of the longest lines in existence.

The year 1870 witnessed a wonderful development, twenty-two cables having been laid, aggregating nearly 11,000 miles. In 1874 a cable was laid from Lisbon to Madeira, 633 miles; thence to St. Vincent, Cape de Verde

Islands, 1260 miles; and from St. Vincent to Pernambuco, 1600 miles, reaching a depth of 3000 fathoms between the latter points.

Great improvements had in the meantime been made in the construction and adaptability of sub-marine cables; conductivity was increased, insulation greatly improved, and tensile strength largely increased with diminished weight. The specific gravity of cables was nicely regulated also, according to the depth of water, and the shore ends were constructed to successfully meet the conditions of each individual case. Paying-out machinery remains the same in principle as that used on board the "Niagara" and "Agamemnon" during their unsuccessful attempt to lay the Atlantic cable in 1857, but minor improvements have been made from time to time. The speed of paying-out under ordinary conditions is between six and seven knots an hour.

The question of the Pacific cable between the United States and Japan has been agitated for many years, and, while the Atlantic cable was still an experiment, extensive surveys were made through Alaska, with a view of reaching the Asiatic coast by the way of Bering straits and Siberia; but the unqualified success of the Atlantic lines was sufficient cause for the abandonment of this long route through a wild and almost uninhabited country. The central North Pacific route from San Francisco to Yokohama, via Honolulu and the Bonin Islands, was supposed to present many features favorable to the enterprise. Captain (now Rear-Admiral) George E. Belknap, U. S. Navy, in the U. S. S. "Tuscarora" made a reconnoissance in 1874, and found a maximum depth of 3115 fathoms between San Francisco and Honolulu, a distance of 2093 miles. Leaving the California coast, their soundings increased regularly to the normal ocean bed, and, day after day they ran with moderate and uniform depths and soft ooze bottom; all indications pointing to a practicable, even simple cable route. But they were greatly surprised one day, when rapidly shoaling water warned them of their approach to a great sub-marine elevation. The summit, having but 388 fathoms over it, was found 710 miles from the Golden Gate. It rises 14,000 feet above the ocean bed, and is commonly known as the Belknap Rise.

From Honolulu to the Bonin Islands, 3140 miles, the greatest depth was 3,287 fathoms, but soundings were not uniform; in fact, a variation of 2000 fathoms or more was

noted. Thence to the Gulf of Yedo, 530 miles, no obstacles presented themselves, and the depths did not exceed 2435 fathoms. Should that route be adopted, a landing at Midway Island, 1220 miles from Honolulu, would break the long stretch to the Bonin group.

Captain Belknap examined the northern route also, and, in a paper read before the Asiatic Society of Yokohama, is found the following graphic description of their remarkable discoveries: "The main object of the Tuscarora expedition was, however, to determine the feasibility of a cable route across the mid Northern Pacific from the coast of California to this port (Yokohama), via Honolulu and the Bonin Islands, and on the homeward run to survey a second route from a point on the east coast of Japan on a great circle running through the Aleutian chain of islands, and ending at Cape Flattery at the entrance of Puget Sound. The Tuscarora put to sea on the 10th of June, to begin the line of soundings on the Northern route.

From what had gone before, it was anticipated that the work ahead would prove to be comparatively light and easy, and all hands were jubilant over the promise that seemed to be in store * * * * But a rude awakening was soon to occur, for hardly had the ship gotten a fairly good offing when, at a distance of only 100 miles from the coast, a sounding was made in 3427 fathoms, the water having deepened more than 1800 fathoms in a run of 30 miles.

The next case was still more startling, for when 4643 fathoms of wire had run out, it broke without bottom having been reached.

This was in the Kuro-Siwo, or Black Stream of Japan, and the current was so strong that the wire, in spite of all that previous experience could suggest, was swept under the ship, finally parting under the strain. The purposes of the survey, and the amount of wire on hand, would not admit of continued experiment, nor was it believed that a cable could be laid in such deep water, encountering so strong a current. The ship was therefore headed in shore, to run up the coast and begin a new line. The great circle was taken up again in latitude 40 degrees north, but here the water also deepened rapidly, and at the third cast from the initial curve of departure, the lead dropped to 3439 fathoms, followed by depths of 3587 fathoms and 3507 fathoms, 40 and 80 miles further on. Then, in the next 40 miles, the lead was found to drop to the great depth of 4340 fathoms, and the Miller-Cas-

ella thermometer came up a perfect wreck from the resultant pressure. The next six soundings, at intervals of 40 miles apart, revealed depths of 4356, 4041, 4234, 4120, 4411 and 4655 fathoms respectively. * * * * *
In view of these remarkable depths developed, the conclusion was irresistible that the great circle route would have to be abandoned and a new line of less depth adopted, if it could be found. It was therefore determined to run back to Hakodate for a fresh supply of coal, then to skirt the Kuriles for a considerable distance before heading over for the Aleutian chain. * * * * * * * * *
Hakodate was left on the 30th of June, and skirting the Kuriles until Lat. 48 degrees N. was reached, the course was laid across to Aggatou, of the Aleutian group. The water deepened rapidly again, and a depth of 3754 fathoms was found about 110 miles west of Cape Lopatka, whence the bed rises, and forms a ridge between that point and the Aleutians like the "Dolphin Rise" on the so-called cable plateau in the North Atlantic. The depression near the Aleutians, and only 70 or 80 miles from land, revealed a depth of 4037 fathoms, thus giving us another surprise on the northern line. The depth on the summit of the ridge was 1777 fathoms.

Turning back now to the series of depths ranging from 3500 fathoms to 4600 fathoms and upward, to the southward and westward of this ridge, it is seen that a trough or basin of extraordinary depth and extent is developed along the east coast of Japan and the Kurile Islands, and under the Black Stream, of greater extent than any similar or approaching depression yet found in any other region of the great oceans. * * * * * * In passing to a comparison of other ocean depths with this deep water off the Japanese coast, let it be noted, that at the eastern end of the Aleutian chain a depression similar to the one discovered at its western extremity was developed, though not quite so deep. The Tuscarora found there a depth of 3664 fathoms, and in 1888 the U. S. Fish Commission steamer Albatross sounded some 200 miles W. S. W. from the position of that cast, and parallel with the coasts of the Aleutians, in a depth of 3820 fathoms. These soundings, 80 and 90 miles from the land, represent depths of over four miles, and from the rugged formation of the group, and the facts which recent hydrographic researches have established, it is more than probable that this depression skirts the

entire length of the chain on its southern or Pacific side."

I might quote at much greater length from this interesting and valuable paper, but time and space will not permit.

With the exception of the trough lying parallel with the southern coast of the Aleutians, moderate depths were found from that group to Cape Flattery.

A third route was examined by the Tuscarora, from San Diego to Honolulu, the greatest depth, 3054 fathoms, being found 400 miles from Oahu.

These lines were not intended as final surveys, but simply as reconnoissances for the purpose of ascertaining in a general way the depth and character of bottom to be encountered. The intervals between soundings ranged between 30 and 60 miles. Nothing more was accomplished toward a Pacific cable until the last session of the Fifty-first Congress, when an appropriation was made for a cable survey from San Francisco, California, to Honolulu, Hawaiian Islands, the work to be done under the direction of the Secretary of the Navy.

The connection of the "Albatross" with this important work dates from September 10, 1891, at which time she was transferred temporarily to the Navy Department for the purpose of making the survey. We were at the time exploring the waters of the Straits of Fuca, having recently returned from Bering Sea, where we had carried the U. S. Commissioners to the Seal Islands.

A few words descriptive of the "Albatross" and such of her special appliances as came into general use during the progress of the cable survey, seem appropriate, as conducive to a better understanding of the methods employed and conditions under which the work was prosecuted.

The Albatross is an iron twin screw steamer, brigantine rigged, 234 feet extreme length, 27 feet 6 inches beam, depth of hold 16 feet 9 inches, and mean draft 13 feet with all weights on board, giving her a displacement of 1110 tons. Her sail area is 7521 square feet, and maximum speed under steam 12 knots per hour. She has a poop cabin, deck house and top-gallant forecastle.

The ward-room is below the spar deck, abaft the engine department, and has excellent accommodations for the commissioned officers. Immediately forward of the engines are commodious laboratories and store-rooms, well arranged and

equipped. The steerage, berth-deck, hold and store-rooms occupy the remaining space forward of the engines.

The Albatross was designed especially for deep-sea exploration, with ample freeboard, easy motion, and great shear fore and aft. The forecastle is practically above the action of ordinary seas, and has always carried the special machinery located on it in safety. When sounding, the stern is always turned to wind and sea, and was designed to meet this unusual requirement without damage to the structure itself or to the delicate machinery which is placed upon it, in the most exposed position; in fact, it is a second bow in its ability to face any sea.

A Sigsbee deep-sea sounding machine is secured to a metal bed-plate, which allows it to project over the stern far enough to permit the wire to hang vertically well clear of rudder and propellers.

This admirable machine, designed by Commander C. D. Sigsbee, U. S. Navy, is based upon the principle of Sir William Thompson, who used a fine steel wire, wound on a metal drum. The rate of paying out when sounding was controlled by a friction rope and permanent weights, and the wire was reeled by one hand, the cranks shipping on the squared ends of the spindle upon which the drum is revolved.

Sigsbee mounted the drum on a light steel frame, resting on a bed-plate, and, on the same bed, placed a small reeling engine having sufficient power to run the wire in at any desired speed. He added accumulator, springs, arranged in upright standards, and attached to a movable pulley frame in such a manner that a rise and fall of the stern, of eight or ten feet in a seaway, may occur without bringing undue tension on the sounding wire, or slacking it sufficiently to throw it off the drum, or cause it to kink. Arrangements are provided for noting at all times the strain on the wire, and other minor improvements tending to the perfection of the apparatus have been added.

Prompt and vertical descent of the wire is insured by suspending to it a spherical weight of 60 pounds, shaped like a cannon ball, and having a hole in its center, through which the sounding cylinder is placed. The latter is Sigsbee's modification of the Belknap cylinder; it has a tumbler, or detaching hook, at its upper extremity, to which the sinker is hung by a wire ball, so arranged that it unhooks the instant it reaches the bottom. The lower body of the cylinder is hol-

low, its base being closed by a self-acting valve, and the bottom specimen is brought up in this space. The sinker having become detached, remains on the bottom.

The vessel being in position, the time required for the weight to descend is about one minute for each 100 fathoms. As soon as it reaches bottom and is detached, it is the custom on board the "Albatross" to steam ahead slowly while reeling the wire in. It is recovered a little more rapidly than it was paid out, averaging about fifty seconds for each 100 fathoms.

The Negretti and Zambra deep-sea thermometer, in combination with the Tanner case, is used on the "Albatross" for observing temperatures. This instrument is accurate, being protected against errors arising from changes of pressure, is very sensitive, records by capsizing; and is independent of indices or subsequent changes in temperature.

Serial temperatures are taken by attaching the requisite number of thermometers to a special temperature wire, which is lowered to the proper depths. As the wire is reeled in, the instruments are removed and read in succession as they reach the surface.

The Albatross has other interesting and useful appliances, but, as they were not used in connection with the survey, it will hardly be necessary to mention them here.

My orders were, to find a practicable route for a sub-marine telegraph cable between San Francisco, California, and Honolulu, Hawaiian Islands. The first consideration was naturally as to the point of departure, which would depend largely upon the locality in which the best landing could be found. It was desirable that it should be as near San Francisco as possible, and had there been a reasonably good landing in that vicinity, we would have accepted it; but a glance at the chart of the adjacent coast will show a large area of comparatively shoal water extending even beyond the Farallones and Cordell bank, over which the ocean swells reach the bottom with scouring effect during great storms.

A heavily armored cable would sustain comparatively little injury from this source, but other and more imminent dangers would await it from ship's anchors and drifting wreckage. San Francisco is the great commercial center of the Pacific Coast, where all routes converge; and the great fleets of shipping which constantly arrive and depart are

subject to the vicissitudes of storm and calm, dense fogs, swift currents, and a dangerous bar, all tending to increase the risk of damage to a cable landed in the immediate vicinity of the metropolis.

During the progress of our work of deep-sea exploration, we examined the entire coast from Cape Flattery to San Diego, running off-shore soundings to the 200-fathom line, occasionally extending them to 1000 fathoms, and while our work was in the interest of the fisheries, it gave us precisely the knowledge required for the inauguration of the cable survey.

It was while prosecuting our investigations off the bay of Monterey in 1889 that particular attention was drawn to the remarkable depression extending seaward from Salinas, or Moss Landing, near the center of the bay. It had been partially developed by the Coast Survey, and the additional information obtained from the "Albatross" soundings promised so favorably that we determined to commence the survey at that point.

The first sounding was made on the morning of October 11, 1891, in 52 fathoms, less than a quarter of a mile to the westward of the head of Salinas pier, a wooden structure about 150 yards in length. A depth of 20 fathoms was found within 200 yards of the beach, and 50 fathoms within a quarter of a mile, with a soft mud bottom. From this point the great trough, constantly widening and deepening, extends seaward in a southwesterly direction, retaining the same soft mud bottom; an ideal bed for a sub-marine cable, where less than half a mile of shore-end would require extra care or protection.

Soundings were taken at very short intervals until reaching the open sea, when a great circle course was laid for the east end of Oahu Island, and the intervals were gradually increased to 5, 10 and finally 15 miles as we approached the normal ocean depth. All traces of sand or other substances of continental origin disappeared in 2061 fathoms, 95 miles from land, the bottom being composed of grey ooze rich in foraminifera. Gradual and fairly uniform increase in depth brought us into 2895 fathoms, 486 miles from Salinas Landing; thence, the bottom became more undulating, and depths decreased between 200 and 300 fathoms, until finally in latitude 32° 44′ north, longitude 135° 00′ west, about 690 miles from the California coast, we found ourselves on the crest of an elevation having a depth of 2014 fathoms, the bot-

tom of partially disintegrated lava. A few fragments were the size of a pea, exceedingly friable, and easily crushed between thumb and finger. The base of the elevation was about 30 miles in extent, and the approach from the northward and eastward quite gradual; but the descent on the opposite side was abrupt, approaching a grade of nearly 20 per cent. Alternate intervals of 2 and 4 miles were maintained while developing it.

Our line passed 40 miles north of the Belknap Rise, an elevation of nearly 14,000 feet above the ocean bed; yet no sign of it appeared, either in depth, contour, or character of bottom.

Leaving the elevation, the line was developed 146 miles further in depths of 2400 to 2700 fathoms, the last hundred miles during a southeast gale with drenching rain and heavy seas. The trip was intended as a preliminary one for the purpose of adjusting compasses, establishing a shore-end, and running the line seaward only as far as convenient.

A second line was run off shore from Salinas Landing, bearing a little westerly from the first one, for the purpose of further developing the sub-marine trough; then returning to San Francisco, on the 24th of October, we completed our outfit, replenished the coal bunkers, and, on the evening of November 4th proceeded to sea for the further prosecution of the survey.

Our own experience, following that of the Tuscarora, seemed to indicate a locality abounding in elevations and depressions of such frequent occurrence as to make it desirable to run a parallel line, for the double purpose of avoiding the elevation above mentioned, and exploring a wider area through what might prove a difficult or impracticable region. With this object in view, we steamed to a point near the great circle route, in latitude 33° 07′ north, longitude 133° 46′ west, and ran a parallel line for 200 miles, 6 to 8 miles to the southward of it, with intervals ranging from 2 to 10 miles.

Passing within 8 miles of the elevation discovered on the preliminary trip, in 2400 fathoms, no sign of it was apparent, except the absence of foraminifera and the presence of particles of lava in the bottom specimens. Normal conditions soon returned, however, and nothing of note occurred until, in latitude 31° 54′ north, longitude 136° 44′ west, the lead revealed a depth of 3186 fathoms, the deepest water found during the survey. This remarkable depression is

worthy of more than passing notice, and fortunately the soundings of the Tuscarora and Albatross enable us to define its limits approximately. It falls over 4000 feet below the surrounding plateau, and extends 70 miles or more in a southwesterly direction, its northern end being from 7 to 10 miles in width, while the opposite extremity expands to 25 or 30 miles.

Normal depths from 2500 to 2700 fathoms continued, to latitude 29° 11′ 30″ north, longitude 143° 17′ 30″ west, where the water again shoaled to 2085 fathoms. A few grains of fine sand were found in the bottom ooze at this station, an occurrence sufficiently rare to occasion remark, as it happened but eight times during the survey while at sea, remote from continental or island influences. It was discovered by means of the microscope, which held a prominent place in this work, every bottom specimen being critically examined by an expert, who by this means frequently gave us the first warning notice of coming changes in depth.

A stretch of about 700 miles now intervened, over what would be called on land a rolling country, with increasing depths averaging nearly 2900 fathoms and a maximum of over 3000. The bottom was, with few exceptions, composed of brown ooze, a trace of lava being found at three stations and sand at two, the latter in 2907 and 2864 fathoms.

The most important elevation on the line was encountered in latitude 23° 14′ 30″ north, longitude 154° 28′ 30″ west, 210 miles from the east end of Oahu. From a base of 300 miles in extent the waters gradually shoaled, over gently rising slopes, to an altitude of 9500 feet above the ocean bed, having on its submerged apex a depth of 1256 fathoms. So gentle was the ascent, however, that the bottom retained its normal bed of ooze even to the summit. Approaching the east end of Oahu a depression was crossed, 60 miles from land, having a depth of 2878 fathoms, mud bottom, all traces of foraminifera having disappeared a hundred miles from the islands.

The shore-platform was reached after a steep ascent, in 570 fathoms, 20 miles from Makapuu Point. Three lines were sounded up the slope, each showing the same general contour, with mud and sand bottom, forming a secure cable bed. In the Kaiwi Channel between Oahu and Molokai, a depth of 300 to 400 fathoms was found, with smooth sand

bottom, but inside of the 200-fathom line, which lies from 1 to 2 miles off shore, frequent coral lumps were discovered scattered at intervals over the sandy bottom.

Of the four points examined on the east and south side of Oahu for a cable landing, Waikiki, about 3 miles from Honolulu seems the best, although three of them may be considered practicable.

Surface currents are strong and somewhat erratic, in the vicinity of the islands, and, when flowing with the tide along the eastern shores of Oahu they not infrequently attain a velocity of 4 to 6 miles, reaching bottom with a scouring effect in considerable depths. There is sufficient drift in the deeper waters of Kaiwi Channel to prevent the deposit of mud, yet not enough to interfere with the growth of many delicate forms of life, which we found in large numbers apparently in congenial quarters, surrounded with ample supplies of food, conditions incompatible with the existence of strong bottom currents.

The impulse to extend our biological researches in the almost unknown waters of Hawaii was very strong, but the element of time was of such importance in the cable survey, that we did not feel justified in doing anything that interfered in the slightest degree with its progress. Yet the scientific results of our island visit were by no means insignificant; the naturalists having secured over a hundred species of fish from various sources. A critical examination of the bottom with beam-trawl and tangles, near the points selected for cable landings, resulted in a small collection of rare and interesting specimens. The following brief list, while by no means complete, will give a good general idea of the fauna of Kaiwi Channel:

In less than 200 fathoms, bottom of sand and coral patches, a variety of fish were taken, besides echinus, ophiurans, crustacea, several species of star-fish, bryozoa, mollusks, algae and fragments of coral.

From 200 to 400 fathoms, with smooth white sand bottom, many kinds of fish were found; among them several species of macrurus, chimaeras, flounders, peristeus, eels, sternoptyx, myctophum, sebastes, monocanthus, etc. Among the invertebrates were star-fish, brisingia, ophiurans, ascidians, holothurians, several species of echinus, silicious sponges, cephalopods, naked mollusks, shells, crabs, prawns, etc., besides several fine crinoids, gorgonians and rare pennatulas.

Surface collecting was made a feature of our daily routine whenever the weather was suitable. Many specimens were taken with a scoop-net while the vessel was hove-to, sounding, a sub-marine electric light being utilized after dark to attract various forms of surface life. The tow-net was used while reeling in the wire after sounding, the vessel then moving slowly through the water. Several hauls were made from intermediate depths also, down to 300 fathoms.

The "Albatross" arrived in Honolulu on the 21st of November, 1891, after sounding the great circle route across the Pacific. From December 2d to the 6th the time was consumed in the examination of various points for a cable landing on the island of Oahu. Leaving the beautiful little harbor of Honolulu on the evening of December 11th, the work of sounding commenced the following morning on a rhumb line, N. 63° E. true, between the extremes of the great circle route.

The circumstances attending the selection of Monterey Bay for a cable landing have already been mentioned, and attention has been called to the line of soundings made by the Tuscarora between San Francisco and Honolulu. The scheme of the Albatross' survey contemplated the developement of a great circle and a rhumb line from Salinas Landing to the east end of Oahu, the routes being practically parallel, although a gradual divergence reaches a maximum of 70 miles in mid ocean, converging again and finally meeting at their southwestern terminals. It included also the Tuscarora's line, which lies midway between them for more than three-fourths of the distance, and covers the intervening space, greatly increasing the value of our work.

Reaching the verge of the shore-platform in 603 fathoms, 20 miles from land, a descent of 1178 fathoms was made in 4 miles, a grade of over 29 per cent., yet it retained its character of mud and sand, with no indications of rocky projections, which so often occur under similar conditions. Each succeeding cast revealed increasing depth until, 75 miles from Oahu, we reached a depression 30 miles in extent, over which the soundings indicated a maximum of 3027 fathoms. Thence, for 160 miles, the average was little more than 2600 fathoms, followed by increasing depths to 3038 fathoms, 370 miles from land, being the deepest cast made on the rhumb line. A mean of about 2900 fathoms was carried 345 miles, to an elevation having a depth of 2346 fathoms; thence 120

miles, with an average of a little less than 2700 fathoms, brought us to another rise with 2375 fathoms.

The slight but constant elevation of the great central plateau continued for 385 miles with a mean of 2600 fathoms, to still another elevation having a depth on the rhumb line of 1924 fathoms. Its general contour was further developed by encircling it with numerous soundings on a radius of 7 miles, the least water, 1779 fathoms, being found 7 miles S. 22° W. true, from the position indicated above. Resuming our course, the lead soon reached a depth of 2573 fathoms, but an interval of 16 miles placed us again on the submerged crest of an elevation 1858 fathoms beneath the surface. The grades were all light, however, and no unfavorable conditions were observed in the bottom specimens.

After traversing another region of comparatively uniform depths, averaging a little less than 2600 fathoms, we reached an elevation lying 28 miles S. 46° E. true, from the great Belknap Rise, having a depth of 2175 fathoms. While the soundings do not positively demonstrate the fact, there seems a strong probability that we were crossing a remote spur of that elevation.

The normal depth, a little more than 2500 fathoms, was soon found again, and the bottom retained its general uniformity for 118 miles, to the limits of a sub-marine valley which extends 24 miles, and reaches a depth of 2773 fathoms. Thence a mean of 2600 fathoms was carried 257 miles, where gradually shoaling waters warned us of our approach to the terminal at Salinas Landing, 170 miles away.

The two lines intersected 35 miles from shore and then followed the same course through what may be appropriately called the "cable trough" which has already been described.

To fully appreciate the magnitude of this undertaking, it is only necessary to remember that the survey of lines aggregating 4511 miles, including the several landings, was made during the winter months; the season of cloudy, rainy weather and boisterous winds, of frequent gales and heavy seas.

We had little cause for complaint during the progress of the survey on the great circle, although the preliminary trip terminated during the prevalence of a southeaster of sufficient force to test the mettle of ship and personnel.

The really serious contest with the wintry elements commenced upon our departure from Honolulu, December 12th, to run the second or rhumb line. Leaving the protection of the land, we soon plunged into a northeasterly gale with heavy cross seas, which continued with slight interruption until the 24th. It would have been a trying time for a small vessel if simply making a passage, but the gravity of the situation was greatly increased by the necessity of strictly following a prescribed route, with frequent stoppages to sound.

Our course carrying us nearly head to the wind, we were obliged to execute the critical evolution of turning the vessel stern to it at every station, thereafter holding her against a rough breaking sea for an hour or more, while engaged in the operation of sounding, and to bring her head to it again upon resuming the course. Although the prosecution of the work under these adverse conditions was attended with no little risk, great discomfort, and excessive wear and tear, there was at no time the slightest evidence of hesitation on the part of the officers toward its vigorous execution.

The responsibility of the vessel, including the necessary evolutions and personal conduct of the delicate and important operation of sounding, devolved upon the watch officers; and it is but simple justice to say that they soon handled the ship with a skill and judgment that would have delighted the heart of old Benbow himself.

All sea-faring men appreciate the risks attending the running of a ship before a gale, with rough following sea, and few there are who do not recollect some notable occasion, when they suddenly lost their wind, leaving the ship at the mercy of the waves. They, at least, will appreciate the dangers encountered by the "Albatross" through that eventful two weeks, during which she extended the survey over 1000 miles.

The elements were propitious during the exploration of the latter portion of the rhumb line; some compensation, at least, for the unusual buffeting we had previously experienced.

That the good ship passed through such boisterous weather without damage to herself, or injury to officers and men stationed at the sounding machine, over the stern, where they were fully exposed to the action of boarding seas, is, it would seem, sufficient evidence of her eminent adaptability to the work in which she was engaged.

Neither of the "Albatross" lines present serious obstacles to the laying of a sub-marine cable; yet somewhat deeper water and more frequent undulations of the ocean bed are found on the great circle. The rhumb line is a few miles longer, but the advantages of more uniform depths and smaller gradients, seem to point to the latter as the preferable line.

There still remained an unsurveyed route, from Point Conception, on the California coast, to Hilo, Hawaii, lying about 150 miles to the southward and eastward of the "Albatross" lines, and about 40 miles shorter between land and land. There was very little known of the physical characteristics of the region, but the magnitude of the proposed undertaking seemed to make its examination advisable, and I reported to that effect to the Navy Department. The disadvantages of the line were not overlooked. An inter-island cable about 200 miles in length would be required to connect with Honolulu, the metropolis and capital of the kingdom; yet, should more moderate and uniform depths be discovered, the advantages would still remain in its favor. It was worthy of investigation at least.

The Navy Department approved of the recommendation, and ordered the "Albatross" to run the line; but on the eve of sailing, an emergency arose which caused her to be diverted from the cable survey, and the U. S. S. "Thetis," Commander George C. Reiter, U. S. Navy, was directed to complete the work. This vessel had been employed on the survey of the Lower California coast, and only required some additional deep-sea sounding apparatus to fit her for the expedition.

Point Conception, from which the "Thetis" line started, marks the northern limit of Santa Barbara Channel, and is one of the points on the California coast nearest to the Hawaiian Islands.

The "Thetis" commenced her survey on the 20th of April, 1892, under the most favorable auspices. Gradually increasing depths were found from the shore line to the normal ocean bed, with remarkable uniformity in the soft and yielding bottom of black and green mud.

The 100-fathom curve was reached 6 miles from land; 1000 fathoms at 47 miles; 2000 fathoms at 84 miles; and the normal depth of 2400 fathoms soon followed, and was carried 116 miles to a mountainous region about 20 miles in extent, over which the soundings varied from 2538 to 2216

fathoms, showing elevations of nearly 2000 feet. Thence, for 100 miles or more, uniform depths not exceeding 2500 fathoms were found, but they soon began the ascent of a sub-marine mountain, which they carefully explored to its summit, 1488 fathoms, or 8928 feet above the ocean bed, the wire showing a depth of 976 fathoms over its crest, with bottom of sand, pebbles and ooze. The ascending angles were easy, but the descent was more abrupt, averaging 1000 feet to the mile for the first six miles. Neither of these gradients constitutes an obstacle in itself, and the elevation, although considerable, presents no engineering difficulties of moment beyond the increased expenditure of material required to surmount it. It will be remembered, however, that sand and pebbles were mentioned among the component parts of the bottom soil, and, being debris from the bed rock, possible outcroppings might prove destructive to a sub-marine cable, but a detour of a few miles would doubtless avoid it entirely.

This was the greatest elevation found on the line, and, following the precedent of the Belknap Rise, which was named after the commander of the vessel making the discovery, it may appropriately be called the Reiter Rise. It lies on the great circle, 405 miles from Point Conception, and 270 miles S. 73° E. from the Belknap Rise.

The lead soon revealed a depth of 2600 fathoms, which was carried for about 335 miles, when another elevation was encountered, having 2127 fathoms of water, but the angles were so small that it cannot be considered an obstruction, although it reaches an altitude of 2400 feet above the sea bottom. The normal depth was quickly reached again, and, at 60 miles, had increased to 2778 fathoms, but shoaled 400 fathoms within the next 10 miles. The line then crossed a depression 20 miles in extent, having a maximum depth of 2656 fathoms, followed by an elevation of 516 fathoms, or 3096 feet; but the conditions all being favorable, it may be passed without further comment.

Uniform depths not exceeding 2690 fathoms were carried about 230 miles, when the water shoaled to 2326 fathoms, the conditions remaining normal except at a station in 2512 fathoms, where rocky bottom was unexpectedly found. Had this occurred but once during the survey, there might exist a reasonable doubt of its accuracy, but subsequent experience seems to have confirmed it.

Increasing depths continued for 52 miles, reaching a

maximum of 2828 fathoms at a point 1112 miles from the California coast, and 938 miles from Hilo. A rugged and peculiarly interesting region followed. After traversing a deep valley 25 miles in extent, a sub-marine mountain was encountered, having an elevation of 6612 feet, and a depth of 1726 fathoms. Descending rather a steep grade, 2618 fathoms was found 7 miles from the crest, and carried about 20 miles to an elevation of 3000 feet, on which was found 2110 fathoms; and over all this mountainous region, particularly near the summits of the elevations, rocky bottom frequently occurred. There is nothing in the gradients to account for the absence of the stratum of ooze which usually covers the ocean bed under similar conditions; neither is there evidence of sub-marine currents of sufficient strength to denude the elevated surfaces of their calcareous covering. Black specks, which in the region under discussion are simply minute particles of volcanic cinders and ashes, are recorded in nearly every bottom specimen; and this, coupled with the rock exposure, seems to indicate recent volanic upheaval.

The inadequate supply of deep-sea thermometers furnished the "Thetis" was unfortunately expended three days after her survey commenced, thus leaving us in ignorance regarding bottom temperatures, a knowledge of which would at least, have settled the question as to present seismic action over this region of rocky exposure.

We have now reached a position on the "Thetis" line 887 miles from Hilo, from which point the depths, instead of being less, exceed those found on more northerly routes; the sounding increasing quite uniformly, reached 2900 fathoms at 575, and 3200 fathoms 360 miles from the island, shoaling again to 2656 fathoms in 90 miles, where it marks the southern limit of a great valley more than 600 miles in extent. Crossing this divide, the line was advanced until, 230 miles from the shores of Hawaii, a depth of 3228 fathoms, the maximum discovered on any of the routes approaching the islands, was revealed. This demonstrated the continuation of the great sub-marine trough guarding the eastern approach to the Hawaiian group, and also that the depression reaches more profound depths as we approach the stupendous upheaval of matchless Mauna Loa.

Another valley, scarce fifty miles in width, bordered on the island side by a rise of 421 fathoms, is followed by a gradual descent until the considerable depth of 3082 fath-

oms is found 38 miles from Hilo. The 1000-fathoms curve was reached at 18, and 300 fathoms at 10 miles from Paukaa light-house, the terminus of the line.

The grade from the ocean bed to the shore platform, although rather steep, presents no unfavorable features, and the same may be said of the shore-end until it approaches the immediate vicinity of the land, where coral patches are scattered at intervals over a sandy bottom.

It rarely happens that a landing can be effected in tropical regions without encountering more or less coral, which would prove destructive to an unprotected cable, but steel armor, now so generally used, insures it against serious injury from that cause.

The conditions at Hilo are not unfavorable; a moderate surf breaks on the beach in ordinary weather, increasing in force during easterly gales, but it does not extend far seaward. The length of shore-end requiring armor protection is not great; neither is the liability to damage from other than natural causes excessive at the point selected for a landing.

Deep-sea temperatures were carefully observed on the "Albatross" lines; on the surface every hour, day and night; bottom temperatures at every third station; and serials at intervals of about 300 miles. The isothermal curves were remarkably uniform, as will be seen by reference to the following table:

DEEP SEA TEMPERATURES—FAHRENHEIT.

Depth	Maximum	Minimum	Mean	Maximum Range
Surface	78.0°	56.0°	67.0°	22.0°
400 Fath.	40.8°	40.0°	40.4°	0.8°
1000 "	36.7°	36.1°	36.4°	0.6°
2000 "	35.5°	34.8°	35.1°	0.7°
2500 "	35.7°	34.9°	35.3°	0.8°
3000 "	35.4°	35.1°	35.2°	0.3°

This uniformity was interrupted, however, on four occasions, as follows: In latitute 36° 25′ north, longitude 124° 03′ west, the bottom temperature was 34.8° in 2112 fathoms, being the lowest found during the progress of the survey. The time-honored belief that temperatures fall as the depths increase does not always hold good, as demonstrated in this case; for at 2000 fathoms, the mean is 35.0° and 35.2° at

3000 fathoms. The extreme variation of temperature was less, however, in the latter case, being 0.3° as against 0.7° in the former.

Again, in latitude 23° 49′ north, longitude 151° 55′ west, in 2985 fathoms, the thermometer registered 41.1°, which, following the normal temperature of 35.2° at the previous station, in practically the same depth, led us to suspect an error in the reading, and, in order to vertify it, a thermometor was sent down at the next station, 15 miles distant, in 3030 fathoms, where it showed 38.9°, higher by 3.7° than the mean at 3000 fathoms. Temperatures a fraction over 35° succeeded, and nothing occurred to attract particular attention until in latitude 30° 38′ north, longitude 136° 33′ west, a bottom temperature of 42.3° was recorded in 2612 fathoms, an extraordinary increase of 7.1° above the temperatures observed at the respective distances of 4 and 10 miles on either hand.

The line crossed an elevation of 754 fathoms, or 4524 feet, 16 miles south and west of the station under discussion, and reached the normal depth of 2411 fathoms 15 miles north and east of it, the high temperature having been found at the point of greatest depression, near the base of a sub-marine mountain of no inconsiderable proportions.

The occurrence of warm and cold bands in the waters of the Pacific is not infrequent, and was reported by H. M. S. "Challenger" and the U. S. S. "Tuscarora;" but, if my memory serves me, the areas of abnormal temperatures observed by these vessels were all between the surface and 2000 fathoms. I shall content myself with the simple statement of facts regarding these interesting phenomena of ocean temperatures, leaving their analyses in the abler hands of the scientist.

The lengths of the various routes surveyed are as follows: The "Tuscarora's" line from San Francisco to Mauna Loa Bay, near the east end of Oahu Island, is 2093 nautical miles; the "Albatross'" great circle line from Salinas Landing, Monterey Bay, to Mauna Loa Bay, is 2091 miles; the "Albatross'" rhumb line, to and from the same points, is 2107 miles. Seven miles should be added to these lines, if the terminus be made at Waikiki. The "Thetis'" line from Point Conception to Hilo, is 2050 miles in length.

The existence of a great central plateau, between the coast of California and the Hawaiian Islands, seems to have been established beyond question. It is shown by the "Tuscar-

ora's'" line from San Francisco to Oahu, and by both of the "Albatross'" lines. It may be said that the depressions lying parallel with the island and continental coasts are depressions simply, and do not imply the existence of a plateau.

A careful study of the surveys will, however, show a general though moderate rise of the ocean bed in the central regions, without reference to the frequent elevations and sub-marine mountains encountered.

The depression of the California coast disappears over the areas between Point Conception and San Diego, as shown by the surveys of the "Tuscarora" and "Thetis," the great central plain extending without interruption to the Santa Barbara Islands and the Coronados.

It is impossible, in a single paper, to discuss all the interesting problems connected with this subject; but enough has been said, to show that careful surveys have demonstrated the practicability of establishing telegraphic communication between the United States and the Sandwich Islands.

There need be no further anxiety regarding the unprecedented length of line, since the recent announcement of the successful opening of telegraphic communication between Brazil and the coast of Africa, through a cable 2103 miles in length.

The work of the surveyor is finished, and the completion of telegraphic communication between San Francisco and Honolulu now rests with the electrical engineer and the capitalist.

In Memoriam.

Aldrich, W. A.
Center, William
Crawford, Andrew
Grant, C. Mitchell
Hobart, W. S.
Hoffman, Hon. Ogden
Hopkins, Moses
Marshall, S. A.
Rev, J. J.
Robinson, L. L.
Shafter, Hon. J. McM.
Simson, Robert W.

U of M

Action of the Society on the Death of the Late Secretary.

DECEASED THE 23D DECEMBER, 1891.

At a meeting of the Society, held January 27, 1892, the following preamble and resolutions, relating to the death of the late Secretary, C. Mitchell Grant, Esq., F. R. G. S., were unanimously adopted:

FELLOW MEMBERS OF THE GEOGRAPHICAL SOCIETY OF THE PACIFIC:

Your committee, appointed at the last meeting of this Society, to draft appropriate resolutions in memory of Mr. C. Mitchell Grant, report as follows:

Whereas, Death has taken from our midst our respected and beloved Secretary, Mr. C. Mitchell Grant, who was the founder of this, the first Geographical Society on the Pacific Coast, having organized it in the year 1881, and who was its Recording Secretary from that date up to the time of his death; and

Whereas, In addition to his claim upon our feelings of love and friendship, both as a member of the Society and as an individual, we recognize in him a traveler of high distinction, as the following record will show:

"Mr. Grant spent many years in Siberia, Mongolia, China and Siam. And between the years 1860 and 1873 he crossed Mongolia eight times.

"In the year 1862, at the December meeting of the Royal Geographical Society, which took place in London on the 8th of that month, Mr. C. M. Grant was proposed as a Fellow of the Society by Sir Roderick I. Murchison, the President, and seconded by General Sir Henry Rawlinson, K. C. B., and Viscount Strangford.

"At this meeting, Mr. Grant read a paper of great interest and practical importance, in reference to the extreme eastern portion of Chinese Tartary. He related the particulars of an expedition made by him across the Mongolian portion of the Great Desert of Gobi.

"The London and China *Telegraph*, in a published notice of this expedition, remarked, that Mr. Grant's journey across

the Mongolian desert was suggested not only by a desire to increase our geographical knowledge of that remote part of the world, but also by that of obtaining information which might be turned to account hereafter, in the organization of an overland route to China by way of Russia.

"The effort is justly regarded as one of the most surprising in the history of modern geographical research.

"The President of the R. G. S. having called on Mr. Gladstone, then the Chancellor of the Exchequer, to offer a few observations upon the subjcct under discussion, Mr. Gladstone stated, that he had always entertained a deep impression with respect to the character of the geographical traveler. It appeared to him, that no ordinary qualities were required to make a man a good traveler, particularly where physical and social difficulties had to be encountered. It required a combination of self-command, of patience, of resolution, of ingenuity, of sagacity, forming an aggregate of demand upon the mind, body and faculties, which it was by no means easy to meet. He considerd it one of the chief prerogatives of the inhabtants of his country, that it had furnished to the world so large a proportion of energetic and enterprising travelers. What he had heard that night, especially in the case of Mr. Grant, convinced him that the breed was not extinct."

Resolved, That in the death of Mr. C. Mitchell Grant, this Society has met with a severe loss, not only the loss of his presence, but that of his constant and successful endeavors to advance its interests; and that to his work in the Society is due its present and future success.

Resolved, That this preamble and these resolutions be spread in full upon the minutes of the Society.

Committee { GEORGE DAVIDSON, President,
H. DURBROW, Treasurer,
JOHN PARTRIDGE, Secretary.

ERRATA.

On page 23, for Steropticon, read Stereopticon.

ADDENDA.

FELLOWS.

The following names were received after this volume had been printed:

B. M. LELONG,
FRANK H. PITMAN,
T. F. TRENOR.

LIST OF EXCHANGES.

On page xx—Mexico—La Sociedad Cientifica "Antonio Alzate."

On page xxi—U. S. A.—Boston City Library, Boston, Mass.

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OF THE PACIFIC.

317 Powell St., Union Square, San Francisco.

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The objects of the Society are to encourage Geographical exploration and discovery; to investigate and disseminate Geographical information by discussion, lectures and publications; to establish in this, the chief city of the Pacific States, for the benefit of commerce, navigation and the industrial and material interests of the Pacific Slope, a place where the means will be afforded of obtaining accurate information, not only of the countries bordering on the Pacific Ocean, but of every part of the habitable globe; to accumulate a library of the best books on Geography, History and Statistics; to make a collection of the most recent Maps and Charts—especially those which relate to the Pacific Coasts, the Islands of the Pacific, and the Pacific Ocean; and to enter into correspondence with scientific and learned Societies whose objects include or sympathize with Geography.

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From the Society
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PROCEEDINGS

OF

The Geographical Society

OF THE PACIFIC.

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PROCEEDINGS

OF

The Geographical Society

OF THE PACIFIC.

Meeting of January 23d, 1883.

ARCTIC ICE NOTES.

By CAPT. HOOPER, U. S. R. M.

The great impenetrable mass of ice which, so far as has been observed by man, entirely surrounds the polar regions, is called the "pack." The loose ice or detached pieces which float near the edge of the pack, and, under certain conditions of wind and current, become a part of it, is called "drift ice," and is designated "patch," "floe" or "field," according to its magnitude, ranging from the smallest pieces to several miles in extent. Icebergs are formed from glaciers, and although found floating on the sea, are entirely foreign to it. The glacier, being formed on land above the sea level, descends in obedience to the laws of gravitation until it meets the sea, where large pieces called "bergs" are detached. The large, high floes of sea ice, which in size resemble the smaller bergs, were appropriately named "floebergs" by Captain Fielding, of the Royal Navy, a member of the Nares Expedition.

Sea ice forms at a temperature of 28°.5 Fah., and at first retains a portion of the salt and other impurities. When its temperature is low, sea ice is brittle, but under a higher temperature it becomes tough and flexible. Successive changes of its condition in this respect eliminate the salt, so that in time it becomes pure, and resembles glacier ice. At times it is difficult to distinguish one from the other. Sea ice, when first formed, is opaque, and is white or grayish in color, according to the condition of the water. If near the shore, or in shallow water, the latter color prevails. As the process of purifying itself goes on, it becomes green, and later (when the salt and other impurities are almost entirely eliminated) it shows a clear, deep blue. It is no unusual thing to see these different colors in the same floeberg, caused by the action of the currents pressing layers of ice of different ages one over the other. As these colors are bright and distinct, the effects in the clear sunlight are often very beautiful. There are also occasional small, yellow patches on the surface of the ice due to the presence of microscopic animalculæ.

The thickness of the ice in the Polar Sea is variously estimated. The specific gravity of sea ice is less than .9, and if the floebergs were regular in form, by measuring the height above water, the depth might be ascertained by a simple calculation. But the irregularities of their form render this impossible; consequently these estimates vary greatly. Dr. Hays mentions seeing ice one hundred feet thick in Smith's Sound. Scoresby speaks of ice in the vicinity of Spitzbergen twenty feet in thickness. Parry, when he saw the Polar Ocean at the western entrance to Melville

Sound, speaks of ice found to be forty-two feet in depth, and expresses astonishment at its enormous thickness. McClure saw ice off the Mackenzie River, and on the west coast of Banks Land, drawing from forty to fifty feet of water, and sometimes even seventy or eighty feet. At one time he saw hummocks ninety feet high. Dr. Kane saw ice sixty feet high. Wrangel encountered hummocks ninety feet high off the north coast of Asia. Captain Nares, R. N., estimates the thickness of the main pack to be upwards of eighty or one hundred feet. A floeberg stranded and turned on its edge near the winter quarters of the *Alert* was measured by Nares and found to be one hundred and twenty feet long, one hundred and five feet broad and eighty feet in depth. This floeberg, which is described as by no means the largest in the vicinity, was shown by calculation to weigh about twenty-five thousand tons. The greatest thickness attained by direct freezing is about eighteen feet, at which thickness the increase by freezing at the bottom does not exceed the waste at the top by evaporation, which goes on slowly but surely at all times. The maximum thickness by direct freezing is generally reached the third winter. It is seldom that more than nine feet forms during one winter. The extraordinary thickness attained by the pack is due to accumulations of these naturally formed layers, as they are forced one over the other by pressure due to currents of air and water. On account of the difficulties of ascertaining the thickness of the ice by measurement, the most reliable way appears to be by noting the depth of water at which it touches the bottom. This we found at Herald Island, Wrangel Island and on the coast of Asia near Cape North to be

about ten fathoms. In Bering Sea we made fast to ice grounded in six fathoms; and passed a number of detached pieces grounded in eight fathoms.

Field ice, when not broken and piled up by the forces to which it is subject, constantly grows smoother on the surface. The hummocks are reduced by melting during the summer, and the water thus formed partly fills the hollows. In winter the hollows are further filled by snow, so that in time the surface becomes comparatively smooth.

The lanes of water separating these floes or fields, and which at times penetrate, to a limited extent, the pack itself, are called "leads" and "water-holes." Places where leads and water-holes are numerous are called by the Russians "polynia." Land ice is that which adheres to the coast. This, when broken and thrown up by the action of the sea, is called "ice-foot." The ice-pack is seldom, if ever, seen from the masthead more than twelve miles, and from the deck not more than seven miles.

Light reflected from the ice to the clouds above is called "ice-blink." The blink may often be seen at a distance of thirty or forty miles, and by it the nature of the ice, whether pack or drift, may generally be determined. The blink, over drift ice, shows dark lines, while over the solid pack, it presents an uniform yellowish color to the horizon. This rule, however, is not invariable. The vapors arising from a small lead or water-hole in the pack will sometimes change the entire appearance of the blink, and give the impression that a large body of open water exists. It is not impossible

that many of the reported discoveries of open polar seas may be accounted for in this way. It should always be borne in mind that the pack can be seen but a short distance—twelve miles at best—and that, under certain conditions, no blink is shown, and that when looking across ice for clear water beyond, or indications of it, a lead may produce as perfect a water-sky, or one in which there is an entire absence of ice-blink, as an open sea. This was frequently observed by Mr. Nelson during his sojourn at St. Michaels, Norton Sound. In the winter time, from an unbroken ice-blink, a few hours' southerly wind would produce a perfect water-sky and horizon, with no indication of ice beyond. Of course the only real effect of this southerly wind on the ice would be to open leads or water-holes of limited extent, which the first change of wind would open again.

The dark shadow over open leads of water is at times so perfect in outline, as to be taken for land. An instance of this came under my observation during my cruise in the Arctic Ocean in 1880. Near Point Barrow the pack was in sight from the deck probably four miles away, when land was reported bearing northwest. The appearance was so perfect that, had it not been for the fact that this part of the sea had many times been sailed over, I should have believed that I was actually looking upon land. Captain Nares attributes to this cause the erroneous report of the existence of land to the north of Robeson Channel by the *Polaris* Expedition, and states that it was only by most carefully noting the movements of the darkened patches that he was enabled to say positively that the reported land did not exist.

In regard to the purification of sea water by freezing, Dr. Kane says that the cold, if intense enough, will by its unaided action, independent of all other considerations, produce from salt water a fresh, pure and drinkable element; but that ice formed in this way, when exposed to a high temperature, becomes infiltrated with saline matter by forces allied to endosmosis. He discovered that the floes which formed in midwinter at a temperature of thirty degrees, were still fresh and pure, while the floes of slower growth, or those formed early and late in the season, when the temperature was higher, were distinctly saline. Ice which two months before he had eaten with pleasure, was now so salt that the very snow which covered it was no longer drinkable. Ice formed with the temperature twenty or thirty degrees below zero was of almost flinty hardness, and when tested with nitrate of silver, gave no trace of salt. Sir Charles Lyell states that sea-water ice is fresh, having lost its salt by the decomposing process of freezing. Dr. Sutherland, in his "Journal of Parry's Voyage," says that sea-water ice is salt, containing about one-quarter part of the salt of the original water, the proportion depending upon the temperature. It is very probable that the lower the temperature the more salt the ice will contain. Parry himself, in his account of his attempt to reach the North Pole by boats, says: "I was desirous also of ascertaining whether any part of the real sea ice was so entirely fresh when melted as to be drunk without injury or inconvenience. For this purpose," he says, "we cut a block of ice from a large hummock about ten feet high above the sea, and having broken, pounded and melted it without any previous washing, we found

it, both by the hydrometer and the chemical tests—nitrate of silver—more free from salt than any which we had in our tanks, and which was procured from Hammerfest." He considered this satisfactory, because in the autumn the pools of water met with upon the ice generally become very brackish, in consequence of the sea water being drawn up into them by capillary action, as the ice becomes more rotten and porous, and he might therefore have to depend chiefly upon melted snow for their daily supply. During the two cruises of the *Corwin* in the Arctic seas, I tried the sea ice many times, and to the taste (we had no means of applying delicate chemical tests) the clear, blue ice, although taken from below the surface of the sea, appeared perfectly fresh. The ice melted and standing in pools on the surface of the floes was also found to be fresh in most instances, and we several times filled our water tanks from them with good, drinkable water. Experiments have shown that successive freezing and thawing of sea water tend to reduce the percentage of impurities which it contains; but I am not aware of these having been carried far enough to render it absolutely pure. After several attempts on board the *Fox*, the specific gravity of sea water was reduced, by repeated freezing and thawing, to five ten-thousandths (.0005). Wrangel says the salt left by evaporation on the surface of the ice is mixed with the snow that falls upon it, and is eaten as salt with food, though bitter and aperient. Dr. Walker, who accompanied McClintock in the *Fox*, and who made a careful and systematic set of ice observations in Baffin's Bay and Davis' Straits during the winter of 1857–8, noticed the saltness of the crystals on the ice, but shows that it could not be due to evap-

oration, as supposed by Wrangel. Evaporation is less in proportion to the cold, while the amount of salt crystals increase in the same proportion. Dr. Walker says when the temperatures of the water and air fall below 28°.3, sea water exposed will in a short time be covered with a thin and almost pellucid pellicle of ice of a very plastic nature, allowing of a great amount of bending, curling and such like accommodation to external circcumstances. In proportion to the decreased temperature this covering becomes thicker and presents a vertically striated appearance, identical with that of salammoniac, gradually disappearing as the mass thickens and gets more compact. Still, the lowest portion, or that most recently formed, always presents this aspect. When this pellicle, or covering, becomes of the thickness of a quarter of an inch or more, small white crystals appear on its surface, at first sparse and widely separated, but gradually forming into tufts, and ultimately covering the whole surface. Mr. Nelson, in his general notes on the climate and meteorology of St. Michaels, says of the formation of ice: "Sludge ice forms in the bays with the temperature at 30°.5 Fah., and in addition the whole surface of the sea, if calm, appears covered with large, oily-looking patches, which slowly increase in area, and as the water reaches 30° the sludge begins to unite. In the oily-appearing spots the water, on close view, has a milky shade, and is seen to be full of extremely fragile laminæ of ice, floating with their edges vertical. These plates, when broken and ground up, form the sludge along the shore. Many of the plates are an inch or more in diameter, but so fragile that a breath destroys them. The bays are sometimes covered with a foot of this sludge, under

which the swell or roll of the sea travels three or four miles; but a fall in the temperature over night consolidates the mass. Ice formed in this way is generally rough, but a rapid and extended fall of the temperature directly after the oily spots appear, sometimes throws a thin sheet of glossy ice over the sea for many miles in a single day."

Arctic ice may be divided into two classes, the first comprising that found in the Polar Ocean, or palæocrystic sea of Nares, and the second the ice found within the channels, sounds and bays of the Arctic archipelagos. The latter seldom exceeds the thickness attained by direct freezing—eighteen feet. It is generally much less, and may be classed as navigable, although its navigation is difficult and often attended with great danger, while the former, as has been shown, attains a much greater thickness—estimated at from twenty to one hundred feet—and, according to the best Arctic authorities, is not navigable. "When once fairly beset by the great polar pack," says Lieutenant Payer, of the Austrian Expedition, "they are, in fact, no longer discoverers, but passengers against their will on the ice."

Captain Nares, who has the honor of having sailed his ship nearer to the North Pole than any other explorer, after describing a narrow escape of the *Alert* from the pack, says: "After our late escape, all could appreciate Captain Buddington's recommendations when the *Polaris* was placed in precisely similar circumstances, to 'get out of the polar pack as quickly as possible.'" Captain Nares further says: "It is either affectation or want of knowledge that can lead any one seriously to recommend any attempt being made to navigate

through such ice. No ship has been built which could stand a real nip between two pieces of heavy ice."

Referring to the report of open water having been seen towards the north from the deck of the *Polaris* when she attained her highest latitude, Nares says: "It is perfectly evident that the report meant merely that disconnected water pools were observed, but not that a water channel fit for navigation existed. In Lancaster Sound or Baffin's Bay a water pool in the pack may, under favorable circumstances, be expected to open out and become navigable; here, with this decided polar pack, it is out of the question that any commander should leave the shelter of the land and force his way into the pack without insuring a retreat if necessary." An admiring friend of Captain McClure, of the Royal Navy, in describing that officer's discovery of the northwest passage, says: "He was last seen, after passing through Bering Strait, carrying a hard press of canvas on the *Investigator*, and standing gallantly for the heart of the polar pack." McClure's own account of it, however, shows that he did nothing of the kind. He carefully avoided the polar pack, fully realizing that his only hope lay in keeping in the land water. At one time, when near the Pelly Islands, the appearance of clear water to the eastward, and a slight roll of the sea, induced Captain McClure to steer a course for Banks Land. After running some hours, with a fresh westerly breeze and thick, snowy weather, the discovery was made that the *Investigator* had run into a blind lead in the main pack for a distance of ninety miles, and was compelled to beat out. In his private journal Captain McClure

refers to this as "an escape which all were truly grateful for, there being no two opinions on the ship as to what would have been her fate, had the ice closed upon the *Investigator*."

When the enormous thickness of this ice is considered, it does not appear necessary to produce evidence to show that it is not navigable. If any were needed, however, we have, in addition to that already quoted, the well-known experience of the *Jeannette* and the *Teghetoff*, which should be sufficient to convince the most enthusiastic Arctic theorist that a ship. once fairly beset, is no longer an explorer.

The earliest date on which I find any reference to the ice in the Arctic Ocean north of Bering Strait and the coast of Asia, is in the year 1610, when a party of Russian fur hunters descended the Yenisei River in boats, with the view of penetrating the coast of the Polar Sea, for the purpose of levying tribute upon the native tribes. But their plans were frustrated by encountering ice. In 1646 Cossack fur hunters made expeditions along the coast to the eastward from the Kolyma, and reported the sea filled with ice, with a narrow lead of open water next the land, in which the explorers sailed two days. The following year an expedition sailed from the Kolyma for the purpose of searching for the mouth of the Anadyr, which the Russians supposed emptied into the Arctic Ocean. This voyage was said to be unsuccessful, on account of the sea being filled with heavy ice. A year later (1648) the experiment was repeated, and with success. A part of the expedition, under command of Dashnoff, actually passed through what is now known as Bering

Strait and reached their destination, where they established a trading post. No mention is made of any obstruction by ice. In 1650 a party of hunters and traders sailed from the Indigirka and cruised to the eastward as far as the Kroma, but were there beset by ice and drifted out to sea, where their vessel was crushed, and the crew escaped over the ice to the land. The early history of that country shows that a regular and quite extensive communication by water was carried on between the Lena and Kolyma through open channels near the land, and always with the pack in the offing. Many attempts were made to reach the New Siberian Islands by water, but failed; although we are informed that in 1667 a party of explorers were driven on these islands by wind, and their boats destroyed.

In 1740 an expedition from the Yenisei, after being prevented by ice for two years from leaving that river, succeeded in reaching a place on the west coast of the Taimyr Peninsula, in latitude 75° 15′, through comparatively open water; but at that point met with impenetrable ice, and turned back. Five years before (1735) two expeditions sailed from the Lena to explore the coast in each direction. The expedition bound to the westward did not get out of the mouth of the Lena until August, and even then did not succeed in making but a short distance, on account of ice. After wintering in the Alensk River, it was again liberated in August, and proceeded along the coast to the northward, with the pack in sight to seaward. On the 31st of August, in latitude 77° 29′, it was stopped by impenetrable ice, and after much difficulty and many narrow escapes, turned back. The expedition to the

eastward, after proceeding along the coast about eighty miles, was stopped by ice, and during the winter nearly the whole party died of scurvy. The following year this expedition, newly manned, penetrated as far as Cape Great Baranoff, where it was again stopped by ice, and returned to the Kolyma.

In August, 1739, Cheluyskin found the sea at Cape Thaddeus, on the Taimyr Peninsula, latitude 76° 47′, entirely covered with unbroken ice, and the following year, Lapter lost his vessel in the ice on the east coast of the Taimyr.

In August, 1778, Cook encountered the pack in the vicinity of Icy Cape, latitude 70° 41′ north, and only succeeded in getting three miles farther north that season. To the westward he found the pack near Cape North. In the following year Captain Clerke, who succeeded to the command after the death of Captain Cook, found the pack ice in latitude 69° 30′ in July, and later in the season as far north as 70° 30′. April 26, 1794, Vancouver found drift ice in latitude 59° 30′, Cook's Inlet being blocked with it. In 1817 Kotzebue found drift ice in 65° north latitude. St. Lawrence Island was surrounded by ice at that time.

In 1820 the pack was encountered north of Bering Strait, in latitude 69° 30′. Kotzebue Sound opened that year on the 27th of July. The following year the pack was found a degree farther north. The same year Wrangel and Anjou found leads of open water about one hundred miles off the coast of Asia—the former between the Kolyma and Indigirka, and the latter off the Kotelnor Islands. During the two years following they were frequently interrupted in their travels over the ice by leads of open water.

In August, 1826, Beechey found the pack in latitude 71° 30′, near Point Barrow, with heavy drift ice farther south. In 1787 Mackenzie found the sea at the mouth of the Mackenzie River blocked in the month of July. In 1848 Richardson found navigable water along the coast between Cape Bathurst and the Mackenzie, and a party of Innuits informed him that for two months each summer the ice in that vicinity left the coast. In 1849 Kellett reached latitude 72° 51′, in longitude 164° 45′ west.

In 1850 McClure and Collinson passed Point Barrow, and the former found drift and pack ice, with a narrow channel of navigable water, along the north shore of the American Continent to Prince of Wales Straits, where he wintered, in latitude 72° 50′, longitude 117° 30′. Collinson reached Point Barrow too late to venture round; but, steaming to the northward a few degrees farther west, he reached latitude 73° 23′, where he was stopped by the pack. This was in September. In the following year Collinson sailed along the north coast of America to Dease Strait, following the navigable channel through which McClure had sailed, with the same impenetrable pack in the offing, and returned a year later under similar circumstances. In 1855 the Arctic basin north of Bering Straits was open to latitude 72° 2′, in longitude 174° 50′ west. In 1861 the southern limit of the pack was found in latitude 68° 30′. The seasons of 1865–6–7 appear to have been remarkably open, north of Bering Strait. In the latter year many of the whalers went as far north as 72° 30′; one reached 73° 5′, in longitude 173° 30. Several went around Point Barrow and some nearly to the Mackenzie River, where they remained until the 15th of September.

The strait between Wrangel Island and the coast of Siberia was nearly free from ice in August of that year.

During the summer of 1878 the steamer *Vega* made the passage along the north coast of Asia, encountering drift ice most of the way and sighting the pack many times. The *Vega* passed the Taimyr Peninsula—the most northern point of the Asiatic Continent—on the 20th of August, steaming through drift ice, and arrived at a point on the Tchooktchee Peninsula, about one hundred miles from Bering Strait, on the 27th of September, where she was frozen in and held a prisoner until the 18th day of July, 1879, when she was released by the breaking up of the ice, and passed south through Bering Strait the following day: the first and only vessel up to the present time to make the passage from the Atlantic to the Pacific by the north coast of Asia, commonly called the "northeast passage."

In 1880 the first whaler passed through Bering Strait on the 22d of May. The same year the *Corwin* encountered ice on the east shore of Bering Sea on the 11th of June, in latitude 60° 50′, and after battling with it for ten days, reached St. Michaels with no other damage than the loss of her screw steering gear. On the 29th of June the *Corwin* passed through Bering Strait and made the circuit of the navigable sea north of the strait, keeping the pack in sight. This navigable sea was of an oval form, about two hundred miles by one hundred in extent, its major axis lying in the direction of northwest and southeast. The *Corwin* entered Kotzebue Sound on the 14th of July through heavy drift ice, and reached Point Barrow on the 25th of

August, the pack at that time being about four miles off shore.

On May 30th, 1881, the *Corwin* passed through Bering Strait, and on June 1st, by following a lead into the pack over one hundred miles, she reached latitude 68° 20′, in longitude 176°, where she was caught in the ice during a blinding snow storm, and barely escaped with the loss of her rudder. On the 13th of July, Kotzebue Sound was found free from ice. On the 30th of July, the *Corwin* reached Herald Island through heavy drift ice, and on the 12th of August she reached Wrangel Island under the same circumstances. On the 15th of August of that year the whalers reached Point Barrow, the ice having left the shore only the day before.

It will be seen by the foregoing that from the earliest date of which we have any account, the ice-pack has remained permanently near the north coast of the Asiatic Continent. Generally, a narrow lead of navigable water exists along the shore during the month of August and part of September. This lead is partly filled with broken ice, and is liable to close at any time by a wind blowing on shore. The Taimyr Peninsula, extending from latitude 73° north to latitude 77° 40′, is bounded on the east, west and north by the ice-pack. In summer the ice is detached from the land by the small streams of water which everywhere trickle down its banks, but always remains near. I can find no record of this peninsula being entirely free from ice. Along the American Continent we have much the same condition—the navigable channel along the shore and the pack in the offing. Indeed, it is no unusual thing for the ice to remain "hard and fast" on the

shore as far south as Icy Cape for several seasons in succession. The ice-pack is generally found near Icy Cape on the east side of the Arctic basin, and near Cape North on the west side, the southern edge of the pack forming an irregular curve between those places. In exceptional seasons large fields of drift ice are found south of this curve, but generally this part of the sea is free from ice in August and September. It must not be supposed, however, that the ice which fills this sea goes south into Bering Sea during the winter months, is all melted during the short season of warm weather. The ice-pack, which is at all times broken and rent by currents and by changes in temperature, is constantly in motion, and with the temperature above the freezing point, a continued wasting away of the ice occurs, owing to the friction of its parts, aided to a certain extent by the direct rays of the sun and by evaporation.

As this wasting and melting goes on all through the polar regions, the southern limit of the pack, under the influence of the Bering Strait current, the outset from the large rivers and the innumerable small streams formed by the melting snow which empty into the Arctic Ocean, is pressed to the northward, closing the open spaces in the pack and leaving the lower part of the sea comparatively free from ice. In the latter part of September and October northeast and northwest gales prevail. These force the heavy ice down from the north and on to the shores of each continent, and sometimes entirely through Bering Strait, leaving open leads and waterholes to the north. Now, however, these are soon filled with new ice, which holds the pack in this southerly position until the melting

and wasting of t following season begins and allows it to retreat to the northward again.

In the Greenland and Nova Zembla Seas, according to the observations of the early navigators and others, the southern limit of the pack is generally found from the 76th to the 78th degree of north latitude; but in what are called "open" seasons navigable water extends to 81° 30′. In 1594 William Barentz encountered pack ice between Spitzbergen and Nova Zembla, referring to which he says: "We came to so great a heap of ice that we could not sayle through it."

In the year 1607 Henry Hudson, in a poorly-fitted vessel of only 50 tons, sailed to latitude 81° 30′ in the Spitzbergen seas, where he encountered impenetrable ice and returned home, reporting on his arrival the impossibility of reaching the Pole by this route, as the sea was filled with ice. Scoresby, in 1806, reached the same latitude in the vicinity of Spitzbergen, but was prevented from proceeding farther by the ice. In 1828 Parry, during his attempt to reach the North Pole by boats, encountered the pack in latitude 81° 13′, and by almost superhuman efforts succeeded, by dragging his boats over the ice, in reaching latitude 82° 45′.

In 1874 the *Teghetoff* was beset in latitude 76° 22′, and after two years' helpless drifting in the frozen ocean, was abandoned by her people, who, on their retreat towards the coast of Nova Zembla, encountered open water in latitude 77° 49′.

In September, 1879, the Dutch Arctic exploring schooner *William Barentz* sighted Franz-Joseph Land on the meridian of fifty-five east longitude. In 1881 the same vessel found heavy ice in latitude 78° north, longitude 65° east, and between the meridians of 45°

and 33° east she found the ice as far south as latitude 76° 30′.

We know by the accounts of all Arctic navigators, from the earliest dates of which we have any record down to the present time, that the region surrounding the Pole, so far as it has been penetrated, is filled with the heavy ice already described, except in the immediate vicinity of land, and there it is open but a few weeks in the summer. Hence we see that the northern limit of navigation depends upon the northern limit of the land. All attempts to ignore this fact have resulted in disastrous failures. The same is true of sledging. According to the best authorities, in the absence of continuous land, sledge traveling has never yet been found practicable over any considerable extent of uneven, closed, frozen sea, although conditions may be found to exist which would enable parties to travel for limited distances by sledge and boat operations combined. We have reason to think that all lands yet discovered, with the exception of Franz-Joseph Land and the west coast of Grinnell Land, terminate several degrees from the Pole. It appears, therefore, that these are the points towards which we must look for a higher northern latitude to be made at some future time.

The distance from the pole at which navigators have been stopped by the ice-pack varies from four hundred to eight hundred miles—the former north of Davis Strait and the latter north of Bering Strait—leaving but a comparatively small area unexplored in which to locate an open polar sea. And when we consider that the ice-pack surrounding this small area is constantly in motion, broken by expansion and contraction of its own parts, due to great changes in

temperature, and changes its position in obedience to currents of air and water, we must believe an open, navigable polar sea an impossibility. Even were no ice formed within the unexplored regions, the surrounding and ever-moving masses, unless prevented by barriers of great strength, must crowd in and fill any temporarily open space.

The thanks of the meeting were voted to Capt. Hooper for his valuable contribution.

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1883.

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